PICTORIAL

Vol 1 only

[1846-47?]

Weybridge
12/9/10.

THE

PICTORIAL GALLERY

OF

ARTS.

USEFUL ARTS.

LONDON:
CHARLES KNIGHT AND CO., 22, LUDGATE STREET.

London: Printed by William Clowes and Sons, Stamford Street.

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THE PICTORIAL GALLERY OF ARTS.

There is an exhibition in London, of great and deserved popularity, whose somewhat learned name denotes its purpose—the *Polytechnic* Institution. It is a repository of *many* arts. There is another establishment which has another Greekish name of much higher pretensions—the *Pantechnicon*,—by which we understand nothing more nor less than Everything *relating to Art*. This must indeed be a wonderful exhibition, if its collections at all realize its title. For what is Art? It is the practical application of knowledge to the production of all things whatever that can administer to the uses of man—to the humblest necessities of the body, to the highest gratifications of the mind. The word Art, then, is all-comprehensive. He that makes a shoe, and he that creates a picture, is equally an artist in the strict sense of the term. The elder writers, especially, make no distinctions in the application of the word Art and Arts. Ben Jonson, for example, says, "Arts that respect the mind were ever reputed nobler than those that serve the body." We now attempt to distinguish between an *artist*, and an *artificer*, or an *artisan*. But these distinctions are essentially modern. The skilful practiser of every science is, to use the expressive term of Lord Bacon, an *artsman*. With this wide range of the term Arts, an exhibition that contains *everything relating to Art* must be a world in little. To take only the larger groups of the productions of Art, it must contain, in the leading division alone which we are accustomed to call the Useful Arts, examples of all the various processes and products that have relation to our *daily sustenance*, the sources and the modes of cultivation, the preparation into a saleable form, and the arrangements for bringing them within the reach of the consumers; the materials which we employ for *clothing*, the rearing and tending of the animals or vegetables which supply them, and the subsequent transformation of them into cloth or leather; the ingenious and often complicated arrangements whereby our secondary wants (if such wants *can* be secondary) of *fire*, *light*, and *water* are supplied; the *houses*, from the hut to the palace, and all the multifarious processes by which these are rendered homes of comfort to civilized man; the means which ingenuity and industry have afforded to us for *traversing the surface of our globe*, whether the wheel-carriages and the roads on which they run, the mighty locomotive and the railway on which it works, or the gallant ship and its thousand accessories; the *metallic riches* which our mines afford, and the means for bringing their produce into the countless forms so familiar to us; the earthy and *mineral sources* from whence, by industrial aid, we obtain our pottery, our glass, our chemicals, and so many other valuable kinds of produce; the combination of science and of constructive art which gives us our lighthouses, our breakwaters, our docks and harbours, and other specimens of *civil engineering;* and not the least, the useful *Arts contributing to Science and Knowledge*, such as Printing, and the construction of Astronomical, Optical, and other Instruments, Clocks, Watches, Chronometers, and a hundred ingenious devices whose excellence constitutes the highest perfection of mechanical skill. Let us pause for a moment and consider how vast must be the building, how complicated the arrangements, how enormous the capital required for the formation of an exhibition in which the processes and products connected with all the useful arts, and even with such leading divisions of them as we have just enumerated, may be adequately displayed. The Colosseum of Rome would be a baby-house compared with such an edifice. Carry the display into the higher branch of Arts, and the building will exceed all the wonders

"Of Babel, and the works of Memphian kings."

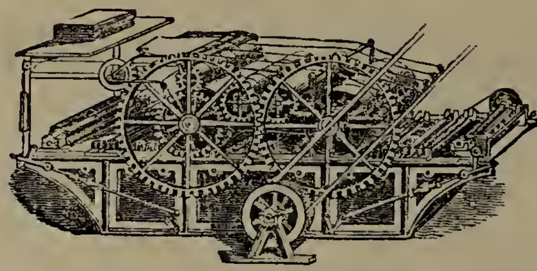
But what no exhibition of real processes and products can accomplish, may be attained in a great degree by

"A PICTORIAL Gallery of Arts."

By the aid of *three or four thousand engravings* we can open to the view the entire kingdom of technical skill in all its more important operations. We can exhibit man, in every region of the earth,

labouring with more or less success to surround himself with those necessaries, comforts, and conveniences, which constitute the elements of civilization. We can show him going forward into the higher range of arts, and surrounding his domestic and public life with the attributes of TASTE, and moving onward and onward till he reach the highest development of the principle of BEAUTY. Here, again, is another kingdom of Art. Inseparably allied are these great divisions of knowledge in practice; and when they are separated essentially in men's minds, there can be no permanent suceess even for what is ignorantly held to belong exclusively to the useful. But, though there be this unity of object, yet for the sake of convenient arrangement, and for leading onward from the simpler to the higher productions of technical skill, our 'Pictorial Gallery of Arts' will have two divisions. The *first* will be devoted to what we have been accustomed to call the USEFUL ARTS; the *second* to what in the same way we have been aecustomed to call the FINE ARTS. But the union of all art will be essentially kept in mind. The *utility* of our FIRST GALLERY is manifest. But when we open our SECOND GALLERY of the FINE ARTS, and display our pictorial representations of ARCHITECTURE, SCULPTURE, and PAINTING, ANCIENT and MODERN, we know that a familiarity with the beautiful sculptures of antiquity, with the noble paintings of the great modern schools, and with the glorious monuments of Grecian and middle-age architecture, must have an enduring effect upon the manufacture of a Worcester tea-cup or a Paisley shawl. Our two Galleries will be "a School of Design" of no inconsiderable value by this union of the useful and the ornamental. We cannot call our work a *Pantechnicon*, but it will be the most complete *Polytechnicon* ever opened for public instruction and amusement.

The great purpose which is to be kept in mind in this and similar works which teach by pictures as well as words, is the expansion of the intellect of all who see and read. What our "PICTORIAL MUSEUM" is to the world of "ANIMATED NATURE," our "PICTORIAL GALLERY" purposes to be to the world of "ART." The "*Museum*" exhibits the great Author of good displaying His power and wisdom in the creation of the wonderful varieties of life with which the earth is filled—all His creatures accomplishing the purposes of their being in harmony with the great scheme of his providence: the "*Gallery*" will exhibit the same benevolent Teacher of man leading him forward from the humblest exercise of his faculties to the most complete development of his intellectual powers, and, through the agency of these powers, enabling him "to subdue the earth," and elevate himself in the scale of being, by the aid of the accumulated knowledge of society, heaped up for him by the experience of many generations. The one work is a sequel to the other. Each has especial reference to the instruction of the People, particularly of the young.



THE PICTORIAL GALLERY OF ARTS.

CHAPTER I.—THE ARTS CONTRIBUTORY TO FOOD.

"The tea-tables of the people at large furnish about a fifth of this great empire's revenue:"—so said a recent writer in the 'Edinburgh Review;' and the statement is such as to render the supplies for the tea-table not an unfitting opening for our subject. It is indeed wonderful that, large as is the sum annually raised for state purposes in this country, the quota derived from such a source should bear such a notable proportion to the whole. When we find that *tea* alone furnishes a revenue of four millions sterling annually, and *sugar* a still larger sum, besides that which is derived from coffee, we may naturally like to know a little concerning the industrial processes connected with these commodities.

TROPICAL PLANTATIONS.

Tea.

It has been aptly remarked that the history of commerce scarcely presents a parallel to the circumstances which have attended the introduction of tea into Great Britain. This leaf was first imported into Europe by the Dutch East India Company, in the early part of the seventeenth century; but it was not until the year 1666 that a small quantity was brought over from Holland to this country by the Lords Arlington and Ossory; and yet for two or three generations past tea has been reckoned among the principal necessaries of life by all classes of the community. To provide a sufficient supply of the beverage produced from this plant, many thousand tons of the finest mercantile navy in the world are annually employed; trading, too, with a people singularly jealous of communication with foreigners.

This plant is indigenous both to China and to Japan, and has been used in the former country from the earliest recorded times; but it is only a particular part of the central provinces which is distinguished as the "tea country" of China: the parts farther north being too cold and those farther south too warm to encourage its growth to perfection. The plant (Fig. 1) is a shrub having the botanical name of *Thea*, and the leaves constitute the tea of commerce. The difference in the qualities of tea does not arise so much (if at all) from difference in the species, as from the mode of culture and the mode of subsequent preparation.

The tea-plant is grown from seeds, which are sown in rows four or five feet asunder; and so many uncertainties are involved in their growth, that it is found necessary to sow as many as seven or eight seeds in every hole. The ground between the rows is kept free from weeds, and the plants are not allowed to attain a higher growth than admits of the leaves being conveniently gathered. The first crop of leaves is not collected until the third year after sowing; and when the plants are six or seven years old, the produce becomes so inferior, that they are removed to make room for a fresh plantation. The leaves are gathered (Fig. 2) from one to four times during the year, according to the age of the tree; the most general number being three, the first of which takes place about April, the second about June, and the third about August. The earliest gathered leaves have the most delicate colour, the most aromatic flavour, and the least bitterness; those of the second gathering have a dull green colour, and less valuable qualities than the former; while the third collection are of a darker green, and least valuable of the three. The quality is also affected by the age of the plant on which the leaves are borne, and by the degree of exposure to which they have become accustomed; leaves from young plants, and those most exposed, being always the best. So particular are the Chinese to ensure the excellence of the finest sorts, that for two or three weeks before the harvest commences, the collectors, who are trained to this business from a very early age, are prohibited from eating fish or other kinds of food deemed unclean, lest by their breath they should contaminate the leaves. They are also made to take a bath two or three times a day, and are not allowed to gather the leaves with the naked fingers, but with gloves. These precautions, absurdly minute as they may to some appear, owe their origin to the evanescent nature of the finer qualities of the tea; for the finest kind may be changed into an inferior tea in one night, if the proper attention be not paid to the gathering.

Then ensue the processes whereby the green leaves assume the wrinkled form so familiar to us. As soon as gathered, they are put into wide shallow baskets, and placed in the wind or sunshine for a few hours. They are then transferred to a flat cast-iron pan, over a stove heated with charcoal, in quantity about half a pound of leaves at a time. The leaves are stirred briskly about with a kind of brush, and are then quickly swept off the pan into baskets. This done, the leaves are carefully rubbed and rolled between the hands, and are next put, in larger quantities, on the pan, and subjected again to heat; but the heat on this occasion is lower than before, and only just sufficient to dry them effectually without risk of scorching. The tea is then spread out on a table and carefully examined; every unsightly or imperfectly-dried leaf being removed from the rest.

This is the usual manipulation for the larger bulk of teas; but some of the finer kinds pass through a more elaborate series of processes. Any one who has visited the Chinese Exhibition at Knightsbridge (and a shilling may be well spent there) has there had an opportunity of seeing pictorial representations of the whole range of operations, painted in that quaint but elaborate style which distinguishes the productions of the Chinese artists.

The distinctions of tea into *Black* and *Green* are distinctions rather of manufacture than of growth. The common names applied are derived in many instances from the districts where the tea is grown. Thus, *Bohea* is named from a particularly hilly spot covered with tea-plantations: and Souchong, Pekoe, Congou, Hyson, &c., are all Chinese names (or rather English imitations of them), having a distinctive and efficient meaning among the natives, although rather vague with us. All teas, by a little variation of the processes, may be made either green or black at pleasure; but in practice the preparation of the respective kinds is carried on in different parts of the Empire, and by different sets of arrangements. In the green teas the leaves only are taken, being nipped off above the foot-stalk or petiole; while of the black tea the foot-stalk is also collected: from whence it happens that the black tea contains much of the woody fibre, while the green is exclusively the fleshy part of the leaf itself.

An important experiment has been made within the last few years, to determine whether any of the British dominions could produce tea of sufficient excellence, and at a sufficiently low price, to render us independent of the Chinese in case of emergency. There is a district called Assam, at the north-eastern extremity of India, to which attention has been particularly directed in this matter. In 1834 it was publicly announced that the tea-plant was indigenous at Assam; and after that it became known that even so far back as 1825 the existence of a kind of wild tea had been recognised near that district. A scientific deputation was sent to Assam to determine the matter; and Mr. Bruce was appointed to superintend tea-plantations there. By degrees more than a hundred plantations were established, and the undertaking assumed somewhat of a commercial character. The East India Company had their plantations, and an "Assam Tea Company" had theirs. From the novelty of the attempt, and the important consequences likely to result from it, the first sales reaped extravagant prices, even so much as twenty or thirty shillings per pound. In 1840 the prices were from seven to eleven shillings, although the value (compared with China tea) was estimated at from three to four. In 1841 some of the Assam tea was sent to Calcutta, and the rest sent to England, where it has been reported on favourably by tea-brokers, who seem to think that its strength and general qualities may be easily improved when its nature is better understood.

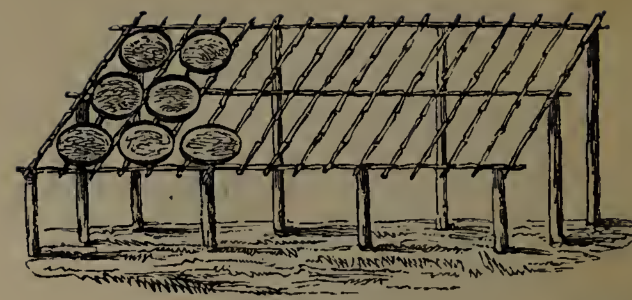
The following is the mode of making black tea at Assam, adopted by the Chinese under the orders of Mr. Bruce. The leaves being brought to the place where they are to be converted into tea, are thinly scattered in large circular open-worked bamboo baskets, and placed on a frame-work of bamboo (Fig. 3). Here they are left exposed to the sun for about two hours, or until they have a slightly withered appearance; the leaves in the mean time being occasionally turned by the hand. The baskets are taken into a covered building, and placed on another open frame, where they are left to cool for half an hour. Being next put into smaller baskets, and placed on a stand, the leaves are taken up between the hands with the fingers and thumb extended, and gently tossed up and down for a few minutes. This drying and handling is repeated two or three times, by which time the leaves feel something like soft leather. The leaves are next put into cast-iron pans fixed in a circular mud fire-place (Fig. 4); and the pan being well heated by a straw or bamboo fire, about two pounds of leaves are spread equably on or in it. While on the fire, the leaves are frequently turned with the naked hand, to prevent their burning; and as soon as they become inconveniently hot they are received by another man in a close-worked bamboo basket, and taken to a table having a narrow rim round it. The two pounds of hot leaves are divided amongst two or three men, and each forms a ball of the leaves allotted to him, which is grasped gently in the hand in the manner shown in Fig. 5; a little force being used to express any juice which may remain in the leaves. The leaves, after being worked in this way and again separated, are spread out on hot pans, again turned about with the hands, and again rolled on the table. They are next put into a drying-basket, where they are spread three or four inches deep, and placed over a glowing charcoal fire free from smoke. As soon as they appear half-dried, and while still rather soft, the leaves are taken off the fire, placed in open baskets, and allowed to remain for some time on the frame. On the following day the leaves are sorted into "large," "middling," and "small," which form so many different varieties of tea; and each sort is again put into the drying-basket. When crisp by the action of the heat, the leaves are thrown into a large receiving-basket. Again they are heated, with another basket thrown over them to reflect back the heat (Fig. 6). Occasionally the basket is taken off the fire, placed on the stand (Fig. 7), and the leaves gently turned, preparatory to a still further heating. When the leaves have become so crisp as to break under the slightest pressure of the fingers, the process is finished, and the tea is packed in boxes for the market.

Such, then, is the history of the little leaf which yields beverage to so many millions. Many nations drink it largely, but the people of China are the most inveterate tea-drinkers upon earth; they take it morning, noon, and night—strong, if they can afford it; and weak, if they cannot obtain better. When Lord Macartney's embassy was in China, the natives in attendance never failed to beg the tea-leaves remaining after the Europeans had breakfasted; and with these, after submitting them again to boiling-water, they made a beverage which they acknowledged was better than they could ordinarily obtain. The beau-ideal of a Chinese cup of tea does not correspond with English notions. The following is Mr. Davis's description of that part of a Chinese entertainment which involves the drinking of this beverage:—"Soon after being seated, the attendants instantly enter with porcelain cups furnished with covers, in each of which, on removing the little saucer by which it is surmounted, appears a small quantity of fine tea-leaves, on which boiling water has been poured; and thus it is that they drink the infusion, without the addition of either sugar or milk. The delicate aroma of fine tea is no doubt more easily distinguished in this mode of taking it, and a little habit leads many Europeans in China to relish the custom. Though the infusion is generally made in the cup, they occasionally use tea-pots of antique and tasteful shape which are not unfrequently made of tutenague (an alloy of copper, zinc, and nickel) externally, covering earthenware on the inside."—Fig. 8 shows the form of some of the Chinese tea-cups, and Fig. 9 one of the metallo-earthenware tea-pots.

How far we ourselves are a tea-drinking people may be somewhat determined by the circumstance that forty

2.—Tea-gathering. (From a Chinese drawing.)

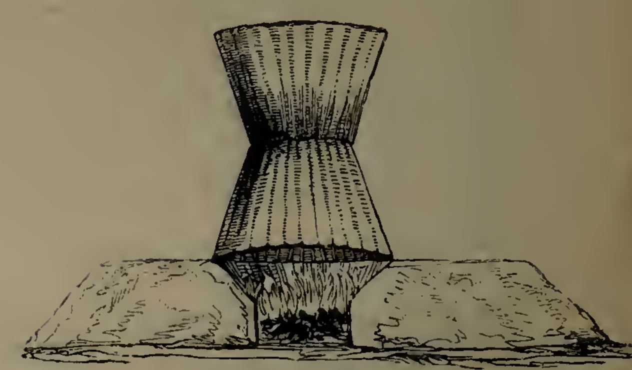
1.—Tea-plant.



3.—Assam Tea-making.

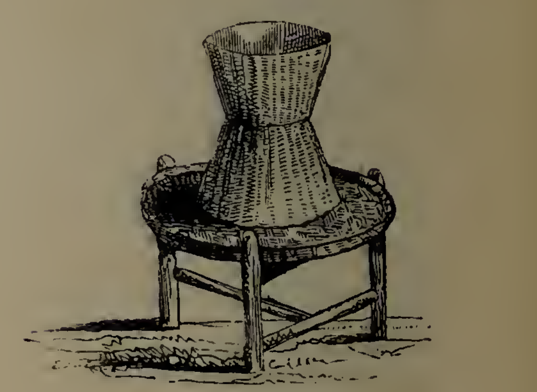
4.—Assam Tea-making.

10.—Cocoa-tree. (Cocoa-nuts.)



6.—Assam Tea-making.

5.—Assam Tea-making.



7.—Assam Tea-making.

8.—Chinese Tea-service.

11.—Fruit of the Cacao-tree; for Cocoa and Chocolate.

9.—Chinese Teapot.

13.—Coffee-plantation in Brazil. (From an engraving in the 'Travels' of Rugendas.)

12.—Coffee, with the Flower and Berry.

17.—The Folly; a floating Coffee-house on the Thames, opposite Somerset-house, A. D. 1709.

18.—Street Coffee-stall.

16.—Interior of a Café at Constantinople.

14.—Egyptian Coffee-service.

15.—Egyptian Coffee-heater.

million pounds of the leaf are now consumed here yearly; and when we remember that Ireland and Scotland do not absorb any large proportion of this quantity, we may probably say that every man, woman, and child in England, poor and rich, sick and well, take on an average about two pounds of tea a-year each.

Cocoa and Chocolate.

There is some little confusion in the minds of many persons as to whether fruit-cocoa and breakfast-cocoa are derived from the same plant. If the orthography had been rightly retained, the doubt would not have arisen, for the breakfast beverage ought to be spelled *cacao*, the o's and the a's being mutually transposed in the two words.

Cocoa-nuts are derived from the cocoa-palm or *cocos nucifera*, an Asiatic plant (Fig. 10) growing in a very singular manner. There are no branches, properly so called; but the leaves, twelve or fourteen feet long each, form a kind of crown or fan-like summit to the tree, beneath which grows a cluster of the fruit or cocoa-nuts: these nuts are collected by the natives who climb the trees. Of this tree the uses are almost incalculably numerous. The roots are chewed; gutters and posts are made of the wood; the young buds form a delicate vegetable; the leaves are manufactured into baskets, lanterns, books, and numerous other articles; the midrib of the leaves forms oars; the bruised end of a leaf forms a brush; the juice of the stem yields palm wine, and afterwards an ardent spirit; the farinaceous matter in the stem is a substitute for sago; the sap yields a dark coloured sugar; this sugar mixed with lime forms a powerful cement; the fruit of the nut is a wholesome food, and its milk a cooling beverage; the coir or fibrous covering to the nut makes excellent cordage; the shell is formed into drinking vessels; the solid matter contained within the shell yields excellent oil for lamps and for medicines—all these services does the cocoa-tree render, but it does *not* give us breakfast-cocoa.

The *Theobroma* is the botanical name for the genus of trees which yields the *cocoa*, or *cacao* (as we had better term it). The tree is indigenous in South America, but grows also in the tropical parts of Asia and Africa. The Mexicans call the tree *Chocolatl*, and hence one of our names for its produce. The trees are evergreens, and bear fruit and flowers all the year through; but the usual times for gathering the fruit are June and December. Fig. 11 will show that this fruit differs considerably in form from the cocoa-nut, the fruit of the *cocos*. The seeds contained by this fruit possess those qualities which we recognise in cocoa and chocolate; and as the opinion is gaining ground that the beverage obtained from them constitutes a valuable article of diet, the importation into this country is becoming large: it now amounts in fact to two million pounds annually.

The mode of preparation to which these seeds are subjected is very simple. When pressed into cakes or reduced to a paste, they form the "cocoa" of the grocers' shops; and when this paste, while hot, is mixed with honey, sugar, or other accompaniments, it forms "chocolate."

A far more important article, however, is

Coffee.

The extent to which this beverage has become part and parcel of the daily food of so many nations seems to point to the existence of salubrious qualities in it, which render its growth and preparation worthy of our notice.

Most persons probably are aware that the unground coffee is the berry of a tropical plant. This plant is a moderate-sized tree, called the *Coffea Arabica*. The tree grows to the height of eight or ten feet, and has long slender branches, on which the leaves and berries grow in the position shown in Fig. 12. The berry is red externally, and has a pale, insipid, and somewhat glutinous pulp, enclosing two hard oval seeds each about the size of an ordinary pea: one side of each seed is convex, while the other is flat, and has a little straight furrow inscribed through its longest diameter; while growing, the flat sides of the seeds are towards each other. The left hand half of the cut shows the entire berry, a berry half extricated from its pulp, the separated seeds, and the flower.

The trees begin bearing when they are two years old, and are in full bearing in the third year. The aspect of a coffee-plantation during the period of flowering, which does not last longer than about two days, is said to be very interesting. In one night the blossoms expand themselves so profusely as to present the same appearance which has sometimes been witnessed in England when a casual snow-storm at the close of autumn has loaded the trees while still furnished with luxuriant foliage. The seeds are known to be ripe when the berries assume a dark red colour; and if not then gathered, they will drop from the trees. The Arabian coffee-planters do not pluck the fruit, but place cloths for its reception beneath the trees. The trees being shaken, the ripened berries drop readily; the berries are afterwards spread upon mats, and exposed to the sun's rays until perfectly dry, when the husk is broken with large heavy rollers made either of wood or of stone; and the coffee, thus cleared of its husk, is again dried thoroughly in the sun, that it may not be liable to ferment when packed for shipment. The method employed in the West Indies differs somewhat from this. Negroes are set to gather such of the berries as are sufficiently ripe, and for this purpose are provided each with a canvas bag, having an iron ring or hoop at its mouth to keep it always distended, and this bag is slung round the neck, so as to leave both hands at liberty: as often as the bag is filled, the contents are transferred to a large basket. In the Brazilian method (Fig. 13) the berries are picked by negroes, put into aprons or into baskets, and then thrown in a heap on the ground.

It is the seed within the berry which forms the well-known coffee of commerce, and not the berry itself. The separation of the two is effected in some places, as above, by breaking the dried berries with heavy rollers; but some planters separate the husk from the seed while the former is yet in a pulpy state. For this purpose a pulp-mill is used, consisting of a horizontal fluted roller, turned by a crank, and acting against a moveable breast-board, so placed as to prevent the passage of the whole berries between itself and the roller. The crushed pulp is then separated from the seeds by washing them, and the latter are spread out in the sun to dry. There still remains a membraneous skin, which keeps the two halves of the seed together, and it is necessary to remove this: which is done by means of heavy rollers running in a trough wherein the seeds are put; and the seeds are afterwards winnowed to separate the chaff.

The coffee-seeds, in this state, are wholly unfitted for the production of the fragrant beverage which has brought the plant into so much repute: they are green, and of a sickly taste; but by a process of roasting they undergo a kind of fermentation, which develops a wholly different flavour within the seed. This roasting is a process requiring much nicety. If burned, much of the fine aromatic flavour is destroyed, and a disagreeable bitter taste substituted. The roasting is now usually performed in a cylindrical vessel, continually turned upon its axis over the fire-place, in order to prevent the too great heating of any one part, and to equalize the action throughout. If coffee be roasted a long time before it is ground, or ground long before it is used, in either case much of the fine aroma is lost. It is advised in the 'Penny Cyclopædia,' that the beverage should be prepared from the roasted berry "by infusion, which is preferable, unless some apparatus be employed by which a kind of decoction is made in a close vessel, such as Parker's steam-fountain coffee-pot. About half an ounce of coffee-powder should be used for every eight ounces (half a pint) of water. In Britain the roasting is generally carried too far; and the subsequent parts of the process, instead of being performed immediately, are often postponed for days or even weeks, by which the aroma is dissipated; when made, the liquor is generally deficient in strength and clearness. The employment of white of egg or fish-skin to clarify is decidedly objectionable: clearness is thus purchased, but at the expense of the strength. The addition of milk (which should always be hot) and of sugar heightens the nourishing qualities of this beverage, and in the morning renders it a more substantial article for breakfast. When taken after dinner to promote digestion it should be without milk, and, where the palate can be reconciled to it, without sugar."

The spread of the use of coffee as a beverage has been very marked and important. The use of the berry was first introduced into Arabia by the Mufti of Aden, about three centuries ago; and by about the year 1550 the berry was publicly sold at Constantinople. The beverage soon became so much relished that the Mohammedan priesthood brought complaints against it; they said that the mosques became deserted and the coffee-houses crowded. The Mufti of Constantinople ordered the coffee-houses to be closed, and employed the police of the city to prevent any one from drinking coffee. But so difficult is it found to rule the tastes of a people, either in matters of diet or of dress, that the government very wisely desisted after a time from their vain attempt, and imposed a tax on coffee instead of interdicting it. It is supposed that the Venetians were the first to adopt the use of coffee in Europe. A letter, written in 1615 from Constantinople, by Peter de la Valle, a Venetian, acquaints his correspondent with the writer's intention of bringing home to Italy some coffee, which he speaks of as an article unknown in his own country. Thirty years after this, some gentlemen returning from Constantinople to Marseilles, brought with them a supply of this luxury, together with the vessels required for its preparation; but it was not until 1671 that the first house was opened in Paris for the sale of the prepared beverage. So far as regards our own country, the first mention of coffee that occurs in the statute books is about 1660, whereby a duty of fourpence per gallon, to be paid by the maker, was imposed upon all coffee made and sold; the first opening of a coffee-house in London having taken place about eight years earlier, by a Greek named Pasqua, who was brought over by a Turkey merchant, and who established this new branch of commercial dealing in George Yard, Lombard Street.

So recent, then, was the origin of coffee; an article of diet which has now attained a sale and demand of great magnitude. It is supposed that the quantity of coffee annually exported from the various countries where it is grown cannot be less than a hundred and twenty thousand tons annually, or two hundred and fifty millions of pounds, besides that which is consumed in those countries themselves. Nearly half of this total quantity is exported from Brazil and Cuba, and is derived from a single plant, which was brought thither from Mocha a century and a half ago.

The Turks, and the Mohammedans generally, are excessively fond of coffee. Of the beverage drunk by the Egyptians, Mr. Lane says, "The coffee (*ckah'weh*) is made very strong, and without sugar or milk. The coffee-cup (which is called *finga'n*) is small, generally holding not quite an ounce and a half of liquid; it is of porcelain or Dutch ware, and, being without a handle, is placed within another cup (called *zurf*) of silver or brass, according to the circumstances of the owner, and both in shape and size nearly resembling our egg-cups. In preparing the coffee, the water is first made to boil; the coffee (freshly roasted and pounded) is then put in and stirred; after which the pot is again placed on the fire, once or twice, until the coffee begins to simmer, when it is taken off, and its contents are poured out into the cups while the surface is yet creamy. The Egyptians are excessively fond of pure and strong coffee thus prepared, and very seldom add sugar to it (though some do when they are unwell), and never milk or cream; but a little cardamom-seed is often added to it. It is a common custom, also, to fumigate the cup with the smoke of mastic; and the wealthy sometimes impregnate the coffee with the delicious fragrance of ambergris. The most general mode of doing this is to put about a carat weight of ambergris in a coffee-pot and melt it over a fire; then make the coffee in another pot in the manner before described, and, when it has settled a little, pour it into the pot which contains the ambergris. Some persons make use of the ambergris, for the same purpose, in a different way; sticking a piece of it, of the weight of about two carats, in the bottom of the cup, and then pouring in the coffee: a piece of the weight above mentioned will serve for two or three weeks. This mode is often adopted by persons who like always to have the coffee which they themselves drink flavoured with this perfume, and do not give all their visitors the same luxury. The coffee-pot is sometimes brought in a vessel of silver or brass (called *'a'z'ckee*), containing burning charcoal: this vessel is suspended by three chains. In presenting the coffee, the servant holds the foot of the *zurf* with his thumb and first finger. In receiving the *finga'n* and *zurf*, he makes use of both hands, placing the left beneath, and the right above at the same instant."

In Fig. 14 some of the vessels mentioned by Mr. Lane are shown. The upper part represents a coffee-service of several *finga'ns* and *zurfs*, together with a coffee-pot, all of silver, and one-eighth of the original size. Below this are a similar *finga'n* and *zurf* one-fourth of the real size, and also a brass *zurf* with the *finga'n* put on it. In Fig. 15 the left-hand vessel is the charcoal-burner, in which the coffee-pot is sometimes placed: the other vessels being charcoal-burners used as chafing-dishes for other purposes.

The practice of drinking coffee without sugar may seem a strange one to English people; but in the East it is so prevalent that an exception to it is often deemed inexplicable. Lieut. Welsted relates an amusing instance of this. "A party of Bedouins were disputing respecting the sanity of Lady Hester Stanhope; one party strenuously maintaining that it was impossible a lady so charitable, so munificent, could be otherwise than in full possession of her faculties. Their opponents alleged acts in proof to the contrary. An old man with a white beard called for silence—a call from the aged among the Arabs seldom made in vain. 'She *is* mad,' said he; and, lowering his voice to a whisper, as if fearful such an outrage against established custom should spread beyond his circle, he added, 'for she puts sugar to her coffee!' This was conclusive."

The introduction of coffee has given origin to a custom which has had considerable effect in the social relations of the countries where it is used; we mean the establishment of *cafés* and coffee-houses. Whether it be that men love to be sipping or smoking, or both, when not actively employed, certain it is that such coffee-houses, with or without the smoking privilege attached to them, are found in nearly all European and Mohammedan countries. In Fig. 16 we see sketched a scene which often presents itself to the notice of travellers in Oriental cities. As long ago as 1660 travellers spoke of the large number of these coffee-shops in the East; for Biddulph, a writer of that day, says, "Their coffee-houses at Aleppo are more common than ale-houses in England; but they use not so much to sit in the houses, as on benches on both sides the street, near unto a coffee-house, every man with his finjon (cup) full, which being smoking hot, they use to put it to their nose and ears, and then sup it off by leisure, being full of idle and ale-house talk." Until about fifteen or twenty years ago, the coffee-houses of Constantinople were thronged every evening with a

motley assemblage of Turks, Armenians, Greeks and Jews, all smoking and drinking coffee. Sultan Mahmoud tried to suppress these *cafés;* but the manner in which the law was evaded reminds us of some of the tricks which our own country could occasionally exhibit. When Mr. MacFarlane was in Constantinople in 1828, he was surprised to find the coffee-houses so few and the barbers' shops so many; but on further inquiry he found that behind the open shop, in which the art and mystery of shaving was practised, there was a little room with all the appliances for a café on a small scale.

The coffee-houses and coffee-rooms of France and England are pretty well known to most persons in either country. But our cut (Fig. 17) introduces us to a kind of coffee-house of somewhat more rare occurrence. This was a floating coffee-house, which, in the time when Addison and Steele wrote, was moored opposite Somerset House; it was a lounge for idle pleasure-seekers; but the company frequenting it grew by degrees so disreputable, that the floating "*café*" was discontinued. As to the street luxury depicted in Fig. 18, those who are out betimes in the morning, especially near the markets, will at once appreciate its character.

Sugar.

Sugar is a commodity involving somewhat more of manufacturing agency than either tea or coffee; for there is a considerable amount of apparatus employed in the West India sugar estates; besides the yet more complex vessels and processes of the English sugar refineries.

Sugar is the juice expressed from the cane of a plant growing in the West Indies and other warm countries called the *Saccharum officinarum.* The sugar-cane is said to be a native of China, and indeed to have been cultivated there two thousand years before it was even known in Europe. For some time after the sugar, in its crystalline form, had found its way to Western Asia, great ignorance prevailed in regard to its nature and the mode of its production; but when Marco Polo returned from his travels, in the middle of the thirteenth century, he was able to give tolerably correct details on these points. The way being thus prepared, the plant was soon conveyed to Arabia, Egypt, Nubia, and Ethiopia, where it became extensively cultivated. Early in the fifteenth century it found its way to Sicily, then to Spain, to Madeira, and to the Canaries; and shortly after the discovery of the New World the sugar-cane was carried to Hayti and Brazil, from whence it spread to all the West India Islands.

The growth of the canes depends very much indeed on the kind of soil; some of them, on new and moist land, attaining a height of twenty feet, while those in dry and chalky ground attain only a height of six or eight. The canes have knotty stalks, producing a leaf at each joint or knot; the number of joints varying from about forty to eighty in each specimen. It is from the uppermost of these joints that new plants are produced: and the operations of the sugar-planter are pretty much as follow:—

The field is prepared by marking out the ground in rows three or four feet apart; and in these lines holes are dug from eight to twelve inches deep, with an interval of two feet between the holes. Where the ground is level, large spaces are left at certain intervals for the facility of carting; but there are many situations on the sides of steep hills where no cart can be taken, and in such cases these spaces are not required, for mules are employed instead of carts. The hoeing of a cane-field is very heavy work, especially in a hot climate; and many of the subsequent operations are also laborious. In those countries where the price paid for labour is exceedingly small, great pains are taken in preparing the ground for the reception of the plants, which are carefully weeded, watered, and freed from insects at various periods of their growth. In about a fortnight after the planting, the sprouts appear a little above the ground; and in about seven months the canes have grown up to a great height (Fig. 19). Mr. Beckford says that a field of sugar-canes when in full blossom "is one of the most beautiful productions that the pen or pencil can possibly describe.... It is, when ripe, of a bright and golden yellow; and where obvious to the sun, is in most parts very beautifully streaked with red. The top is of a darkish green; but the more dry it becomes, from either an excess of ripeness or a continuance of drought, it assumes a russet-yellow colour, with long and narrow leaves depending; from the centre of which shoots up an arrow like a silver wand, from two to six feet in height, and from the summit of which grows out a plume of white feathers, which are delicately fringed with lilac dye, and indeed is, in its appearance, not much unlike the tuft that adorns this particular and elegant tree."

It is from the stem of the plant thus graphically described that the juice, afterwards to form sugar, is obtained. When the canes are fully ripe, they are cut nearly close to the ground; and being then divided into convenient lengths, are tied up into bundles, and conveyed to the sugar-mill. This mill consists of three iron cylinders, sometimes standing perpendicularly in a line with each other, and at other times placed horizontally and disposed in a triangle, so adjusted that the canes, on being passed twice between the cylinders, shall have all their juice expressed. This, as it falls, is collected in a cistern, and immediately placed under process by heat to prevent its becoming acid. The juice is conducted along a gutter to large flat-bottomed pans called *clarifiers*, capable of holding from three hundred to a thousand gallons; each of these is placed over a fire. A certain quantity of lime, or lime-water, is put with the juice into the pan, to effect the separation of the feculent matters contained in the juice; and when this is done, the juice is subjected to a very rapid boiling in order to evaporate the watery particles, and to bring the syrup to such a consistency that it will granulate on cooling. The syrup is then ladled either into open wooden boxes called *coolers*, or put into a large cylindrical cooler; here it cools slowly, and is brought to the state of a soft mass of crystals imbedded in molasses, or a thick, viscid, but uncrystallizable fluid. The crystals are next separated from the molasses, in a distinct building called the *curing-house.* The mass is put into casks having small holes in the bottom, each hole partially filled by the stalk of a plantain leaf; the crystals remain in the cask, while the molasses trickles slowly through the perforations into a large flat reservoir beneath. After this, the sugar is ready to be packed in hogsheads for shipment, and the molasses to be distilled for rum.

Operations such as are here slightly described give to the Jamaica sugar-farms a very busy and bustling appearance. Coffee-plantations are mostly formed on high ground, but sugar-farms are more frequently near a running-stream (Fig. 20), for the sake of water-power to work the mill. A sugar-estate commonly consists of three parts; one-third canes, one-third pasturage, and one-third woodland. The woodland furnishes a supply of building-timber and of fire-wood for the farm. The chief buildings, on an estate of (say) about a thousand acres, are a mill, moved either by water or by mules; a boiling-house, containing copper clarifiers, and other pans or boilers; a curing-house, sufficient to hold one-half the crop, and containing a molasses-cistern capable of holding six thousand gallons; a distillery-house, with stills, cistern, pumps and other necessary apparatus, and convenience for storing the stock of rum; two open sheds for containing the "trash," or spent canes; a hospital for the sick negroes; store-rooms for securing the plantation utensils and provisions; shops for carpenters, coopers, wheelwrights, and blacksmiths; a stable for about sixty mules, with a corn-room above; offices for the book-keepers, and a residence for the overseer.

The late Mr. Lewis has left an interesting account of the general economy of the sugar-plantations of the West Indies, from which we may glean a few particulars. The houses of the planters are generally built of wood, partly raised upon pillars, and consist of a single floor. A long gallery, terminated at each end by a square room, runs the whole length of the house; on each side of this gallery is a range of bed-rooms, and the porticoes of the two fronts form two more rooms, with balustrades and flights of steps leading to the lawn. A veranda runs round the whole, with shifting Venetian blinds to admit the air. A few store-rooms and a kind of waiting-hall complete the arrangements of the house; for none of the domestic negroes sleep there, all going home at night to their respective cottages and families. The negroes' houses are composed of wattles on the outside, with rafters of wood, and are well plastered and whitewashed within; they consist of two chambers, one for cooking and the other for sleeping, and are in general well furnished with chairs, tables, a bedstead, and plenty of bed-clothes; for, in spite of the warmth of the climate, the negroes feel very chilly after sunset. Some of the villages in which they reside are quite picturesque; each house is surrounded by a separate garden; and the whole village is intersected by lanes bordered with sweet-smelling and flowering plants.

There is much animation in the daily proceedings of a sugar-farm. "One band of negroes is carrying the ripe canes on their heads to the mill; another set is conveying away the trash after the juice has been extracted; flocks of geese are sheltering from the heat under the trees; the river is filled with ducks and geese; coopers and carpenters are employed about the puncheons; carts drawn by six, others by eight oxen, are bringing loads of Indian corn from the fields; the black children are employed in gathering it into the granary, and in quarrelling with pigs as black as themselves, who are equally busy in stealing the corn whenever the children are looking another way."

Besides the sugar-cane there are many plants which yield sugar, such as one particular species of the maple (Fig. 21), growing in North America. It is supposed that the sap or juice of this species would give sugar enough for the whole consumption of America, were it not cheaper, except in remote districts, to obtain West Indian sugar. The average produce in Canada is said to be from two to four pounds from each tree in a season; and that two men can attend to three or four hundred trees. It is to emigrants principally that the value of these trees is apparent. At the proper season of the year an incision is made in the trunk of the tree by means of a gouge, and a hollow piece of wood is inserted in the incision to act as a spout; the sap then oozes out slowly, and falls into a vessel beneath, from whence it is carried to the boiling-house every evening. The sap is strained into pots or kettles, and then boiled down until the liquid assumes the consistency of a syrup. From thence it is transferred to another vessel to cool; and by a succession of processes resembling in miniature those adopted for cane-sugar, the juice is brought to the granulated state, while the scum and sediment are allowed to ferment into a tolerably good kind of vinegar.

The beet-root, and many other kinds of plants, may be made to yield sugar by processes more or less analogous to the above; but we may pass over these, and say a few words respecting *lump* or *loaf* sugar.

It is perhaps not wholly unnecessary to remark, that loaf sugar is not a particular *kind*, obtained from a particular species of cane, but that it is common brown sugar carried to a higher degree of crystallization and refinement, whereby it loses still more of the molasses which gives the brown colour to common sugar. The refining is carried on in England, in very large buildings, somewhat in the following manner:—

A very coarse brown kind of sugar is brought in hogsheads from the West Indies, and, when removed from these, it is put into large vessels, where it is dissolved in water. The sugar as brought to England, notwithstanding the ordeal it has undergone abroad, still contains colouring matter, molasses, and earthy and other impurities, all of which must be removed before white sugar will be obtained. Lime-water is admitted to act on the liquid sugar, and collects all the earthy and other impurities, so that the liquid can flow without them into another vessel—the *filtering* vessel, destined to remove the brown or blackish colour from the liquor. This vessel is very curiously arranged. It contains a number of cloth tubes about three inches in diameter, suspended from a perforated plate near the top of the vessel; and the dark-coloured syrup or liquid, entering these tubes, filters through the cloth into a receptacle beneath, leaving within the tubes nearly all the remaining impurities, and coming out with a much brightened colour. Lastly, the liquid is de-coloured by filtering through a thick bed of pounded charcoal, which brings it to a clearness almost equal to that of water.

Here, then, we have a mixture of sugar and water, cleansed from all impurities except the molasses of the sugar; and to remove this is the next point. The liquor is conveyed into a *sugar-pan* or *boiler* (Fig. 22), consisting of one vessel within another, steam being admitted between the two to heat the liquid. The pan is fitted air-tight, but is provided with one opening to admit the liquid, another at which it may flow out, a third for the admission of steam, a fourth at which a man may insert a kind of key or plug, to draw out a little of the liquid to test the progress, and one or two others. All these are made air-tight, in order that a vacuum may be produced in the pan above the sugar, and that the boiling may take place at a low temperature. The steam makes the liquid boil, the water evaporates from the sugar by degrees, and leaves the latter as a thick granulated mass, which is allowed to flow out of the pan, through a hole in the bottom, into a receptacle in the room beneath.

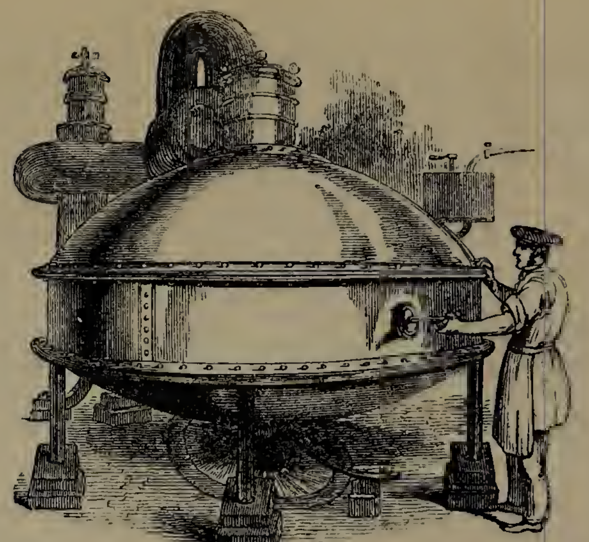
The mass is next heated to a higher temperature in large open vessels (Fig. 23), stirred continually, and then ladled into copper scoops or basins, by which means it is conveniently poured into iron moulds ranged by hundreds on the floor of a large room (Fig. 24). These vessels, shaped like sugar-loaves, have a small hole at the apex or lower point of each, stopped up with a plug; and after the mixed sugar and syrup has remained several hours in the vessels or moulds, the plug is removed, the mould is placed within an earthern jar, and the uncrystallizable syrup drops slowly out, leaving the white sugar as a crystallized lump. All the syrup has, however, not yet left the sugar; and to effect the complete removal a mixture of fine sugar and water is allowed, two or three times over, to filter through the mass of sugar, carrying with it all the remaining syrup, and leaving the beautiful mass of crystals almost in a purely white state. When this syrup, by various processes, has been made to give up every particle of sugar capable of crystallization, the remainder, which assumes the state of a black thick liquid, becomes the *treacle* of the shops.

When the masses of sugar in the mould have become solid and nearly dry, the impure surface is scraped off with a small triangular tool (Fig. 25); the loaves are removed from the moulds by a smart blow; the tops or points are deprived of any discoloured portion by a sort of lathe or circular cutter (Fig. 26), and the loaves are placed in a highly-heated room, being first wrapt in paper to prevent discolouration. When thoroughly dried in these store-rooms the operation is finished, and the white sugar—a symbol of gentility in the opinion of many who use brown—is ready for sale.

These details will have shown, as was before stated, that many industrial processes are involved in the preparation of sugar for the market; and when we know

21.—Sugar Maple-tree: Collecting the Juice.

23.—Sugar-refining.



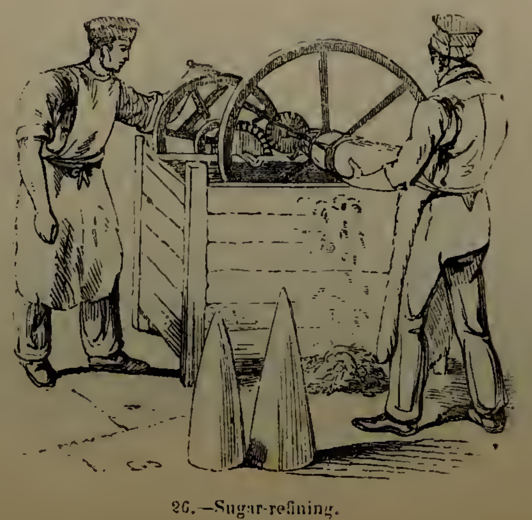
22.—Sugar-refining.

19.—Sugar-Canes.

24.—Sugar-refining

20.—A Jamaica Sugar-Farm.

25.—Sugar-refining.

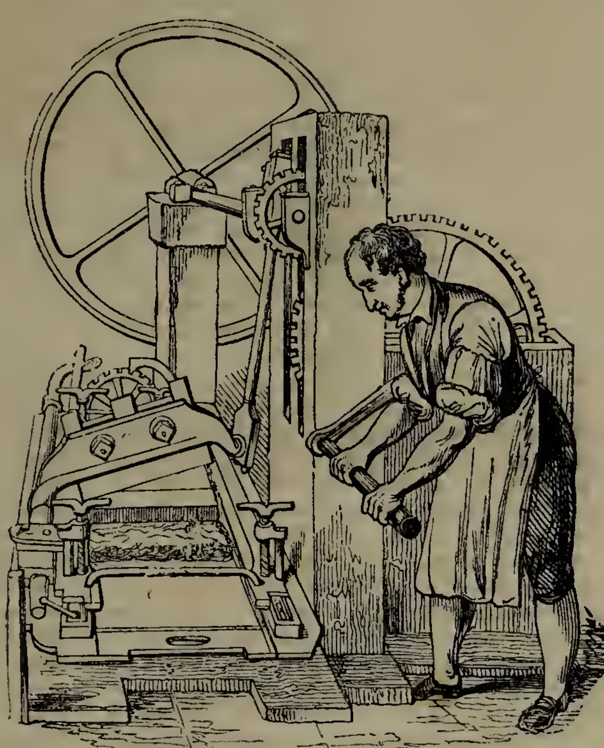


26.—Sugar-refining.

28.—Tobacco Warehouse: London Docks.

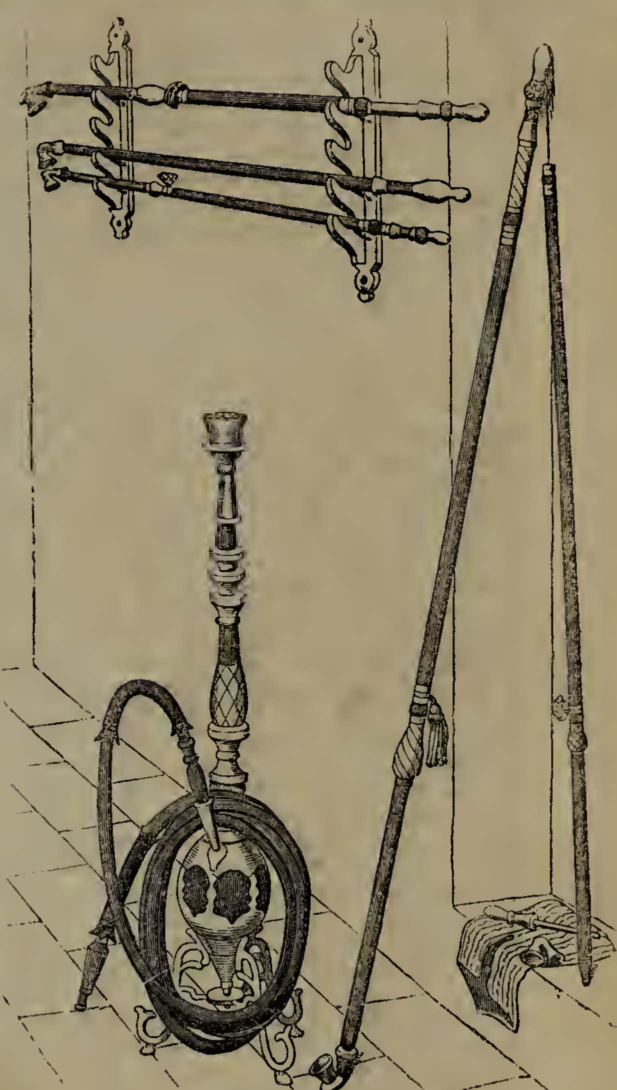
27.—Tobacco plant.

32.—Cigar-making.



30.—Shredding Tobacco-leaves.

31.—Making "Pig-tail" Tobacco.



34.—Egyptian Pipes.

29.—Tobacco Kiln: London Docks.

33.—Cigar-making.

35.—Chinese Opium-pipe.

that five hundred millions of pounds of this commodity find their way into this country yearly, all of which have undergone the processes of granulation into brown sugar, we may form some little guess at the importance of the matter.

Tobacco.

There is a curious connection between the articles of diet already noticed and the one about to be noticed; a connection rather of art and commerce than of natural qualities. We can hardly consider tobacco and snuff to be articles of food, though to many persons they seem to serve as such; yet the agricultural and commercial features of this produce present much analogy to those of tea, coffee, and sugar. All require large plantations; all come either from Asia or America; all give rise to large shipping arrangements; and all contribute very notably to the national revenues.

Tobacco is the leaf of the *Nicotiana Tabacum*, a tropical herbaceous plant, rising with a strong erect stem to the height of six or eight feet, with a fine handsome foliage (Fig. 27). When full grown, the stalk near the root frequently attains a diameter of more than an inch. The leaves, which are of a light green, grow alternately at intervals of two or three inches on the stalk; they are oblong and spear-shaped; those lowest on the stalk are about twenty inches long, and they decrease in size as they ascend, the top leaves being only ten inches long by five broad. The young leaves, when about six inches long, are of a deep green colour and rather smooth; but, as they approach maturity, they assume a yellowish tint and a rougher surface.

In Virginia, the centre of the tobacco-growing districts, the kinds of soil chosen for the cultivation are the chocolate-coloured mountain-lands, and the light black soil in the coves of mountains and the richest low grounds. The ground is prepared in two ways, one for the seed, the other for the transplanted sprouts. The seeds are sown in nursery-beds called *patches*, about March or April; and the young sprouts being ready for transplanting in a month's time, preparations are made accordingly. Hillocks, about eighteen inches high, are raised in parallel lines, so as to form squares four feet by three. The sprouts being about five inches high, are carefully taken out of the ground, conveyed in baskets to the hillocks, and there planted.

When the plant is ripe for cutting, the cutters, each of whom is furnished with a sharp strong knife, proceed regularly along the rows of plants, cutting only such as appear to be ripe, leaving the rest for future operations; the stalks are cut almost close to the ground; and such of them as are sufficiently thick are slit down the middle, to hasten the drying. The leaves are then *cured* in large open barns, where they hang upon slender sticks, no two plants touching each other, but arranged in rows and tiers till the barn is completely filled. If the open air alone does not effectually act on the leaves, smothered fires of rotten wood are kindled, to hasten the process, the object of which is to give a kind of elasticity and toughness to the leaves. When the tobacco is "in case," as it is called, it is taken down from the sticks; and a party of negroes —men, women, and children—sit in a circle on the floor of the tobacco-house, and pull the leaves from the stalks, handing the former to two men placed in the centre, who distribute them into separate groups according to their qualities, generally three in number.

The tobacco, as brought to England, is in two different forms, known technically as "strip-leaf" and "hand-work;" the former being that in which the stem or central rib has been stripped from the leaf before being packed in the hogsheads, and the latter being the leaf and stem together. The two kinds therefore involve rather different arrangements on the part of the planters. For the "strip-leaf," the stripping is effected by taking the leaf in one hand, and the extremity of its stem in the other, in such a manner as to tear them asunder in the direction of the fibre. The leaves, whether stripped or not, are tied up into small bundles, and left in heaps on a wooden platform, where they undergo a "sweating" or slight fermentation. When this is finished, the tobacco is packed in hogsheads for shipment, about one thousand pounds' weight being put in each hogshead. This is a process requiring much care; for the tobacco is pressed in until it becomes nearly as compact as a mass of wood.

When the hogsheads come to England they are deposited at the tobacco-warehouses in the Docks at London, Liverpool, and elsewhere, before getting into the hands of the tobacconists. The tobacco-warehouse at the London Docks is a vast place, containing ranges of hogsheads frequently amounting to twenty thousand at one time, and containing altogether twenty million pounds of tobacco! The reason why so large a quantity is kept here at once is, that the high duty, payable on every pound of tobacco, is not demanded so long as the cargo remains stored in the warehouses; and the owners therefore delay to pay the duty and remove the tobacco until they have got a purchaser for it. As the tobacco is often more or less injured in packing or in coming over, the owner will rather lose the injured part altogether than pay the duty on it. Accordingly many such scenes are presented as that shown in Fig. 28. The hogsheads are opened, the tobacco weighed, and any injured portion is cut away with long knives; so that the owner may pay duty only for the good portion. In order that these cuttings may not get into the market, they are wholly burned in a kiln (Fig. 29) attached to one corner of the tobacco warehouse.

The duty being paid, and the hogshead of tobacco having been consigned to the hands of a tobacco-manufacturer, the leaves are dug out piecemeal from the hard mass, and separated one from another by being moistened with water, and the small bundles untied. If the stem has not been removed from the leaf at the plantations, it is done when the tobacco arrives in this country, by folding the leaf along the middle, and dexterously ripping off the stem by means of a small instrument. A great number of the leaves are then pressed together into a hard compact cake, and shredded very fine by means of an ingenious machine (Fig. 30), in which a cutting blade chops the leaves to narrow fibres, and the mass moves onward by degrees to adjust itself to the position of the cutter. The shredded tobacco is put into a receptacle or box as it is cut.

There are, as most smokers are aware, many varieties of tobacco, which owe their points of difference to many different circumstances,—thus, "bird's eye" has little pieces of the stem shredded up with the leaf; "returns" is made of the lightest coloured leaves; "shag" is made from the darkest leaves, much sprinkled with water before being cut; "orinoco" is a kind named from the river near which it was first grown; and "kanaster" from the name of the kind of rush baskets in which it was first imported. The oddly named "pigtail" is a strong kind of tobacco made up into a pipe or cord in the following curious manner. The leaves are spread out flat, in a row, on a long bench, and a man, with a kind of flat board attached to his hand, rolls these leaves up into a cylindrical form, while a boy (Fig. 31) turns a spinning-wheel, which gives to the cord sufficient twist to make it hold together; the "pigtail" is afterwards made up into a ball and steeped in tobacco-water to give it a dark colour. "Cigars" are another form into which the tobacco is brought. A boy takes the unstripped leaves, and seated on a stool (Fig. 32) strips the stem from the leaves, handing the latter to another person (Fig. 33), who spreads a leaf out before him on a bench, cuts it to form something like one of the stripes of a balloon, puts a few fragments of tobacco on the leaf, rolls it with his hand to the cigar-form, twists one end to keep it tight, and cuts off the other end square. If the reader will bear in mind that imported cigars pay a duty of nine shillings a pound, he will probably not be much surprised to learn that "fine old cubas" and the cheap "havannahs" have had much more to do with Whitechapel than with either Cuba or Havannah, in respect to their manufacture.

Snuff is another form in which tobacco enters into daily consumption. Some kinds are made from the stalk alone, some from the leaf alone, some from stalk and leaf together, some are "high-dried" or almost scorched, some are more or less scented—in short, provided the leaf be reduced to powder, the snuff-maker has an almost unlimited range of variations in his power to suit both the taste and the purse. In all cases the tobacco is dried, and then ground, in the preparation of the snuff.

The social usages attending the introduction of this plant, like those connected with coffee, are not a little striking. Almost every great capital has houses in plenty, where smoking is the staple entertainment or occupation; and the *pipes* in which the tobacco is smoked give rise to a distinct and sometimes an extensive manufacture. In England these pipes are made of clay; but in the East they are made of costly materials, and of very fanciful forms: witness those sketched in Fig. 34. Some of them are so formed that the smoke passes through water, or rose-water, before reaching the mouth; and the stems or tubes are so long, that the cleaning of them is the occupation of a particular class of men in Cairo, who effect the cleansing with bits of tow wrapped round long wires; receiving about one quarter of an English farthing for cleaning a pipe.

The opium-pipe of the Chinese (Fig. 35) bears some analogy to the tobacco-pipes of other countries, and is, like them, a means for conveying into the lungs the smoke from a smouldering vegetable substance. The tobacco smoke, as we all know, comes from the leaf; but the opium smoke is derived from a dried juice obtained by incisions in the opium-plant.

Tobacco, snuff, and opium, have many sins to answer for, and have been subjects for many grave animadversions; but the most whimsical of those charges, perhaps, is a sort of financial estimate of the evils of snuff-taking by the late Earl Stanhope: "Every professed, inveterate, and incurable snuff-taker, at a moderate computation, takes one pinch in ten minutes. Every pinch, with the agreeable ceremony of blowing and wiping the nose, and other incidental circumstances, consumes a minute and a half. One minute and a half out of every ten, allowing sixteen hours to a snuff-taking day, amounts to two hours and twenty-four minutes out of every natural day, or one day out of every ten. One day out of every ten amounts to thirty-six days and a half in a year. Hence, if we suppose the practice to be persisted in for forty years, two entire years of the snuff-taker's life will be dedicated to tickling his nose, and two more to blowing it. The expense of snuff, snuff-boxes, and handkerchiefs, will be the subject of a second essay, in which it will appear that this luxury encroaches as much on the income of the snuff-taker as it does on his time; and that by a proper application of the time and money thus lost to the public, a fund might be constituted for the discharge of the national debt."

The four varieties of tropical produce which have engaged our attention, involve a certain amount of manipulative art, subsequent to their culture, and are therefore fittingly noticed here; but where there is simply *growth* to record, it does not form part of our plan to enter into description. Thus, all the luscious fruits and fragrant spices of the East, though matters of much interest, offer little that comes within our scope, and therefore need not detain us; the same may be said of many other sources of food, both in our own and in foreign countries. But when we come to the all-important article *bread*, in its numerous forms, the matter assumes a different aspect. Here many varieties of industrial art are brought into play, from the digging of the ground to the baking of the bread. Indeed so paramount is it, that nearly all which we can here appropriately touch upon in respect to Agriculture, may be grouped under the heading of

CORN-HUSBANDRY.

The wheat, the barley, the oats, and the rye, which constitute the chief varieties of corn-bread, are the main subject of the *arable* department of agriculture, or that which derives its name from the *ara* or plough indispensable to the culture. Land in general is classed under the five headings of arable, grass-land, woodland, pasture, and waste; the last four of these explain their own meaning, and are all of much less importance, in an agricultural point of view, than arable or corn land.

When we come to look a little into the nature of the industrial operations here involved, we find that they consist, 1st, in the selection and preparation of the ground; 2nd, the selection of the kind of grain, and the interchange of other crops with these to improve their growth; 3rd, the sowing and culture of the crop; and lastly, the harvesting and storing of the produce. A few columns of description, and thirty or forty illustrations, will enable us to catch the broad features of such of this series as involve anything like mechanical art.

Corn-land and Manures.

The mould, or vegetable soil, in which seeds are sown is very different in character from the subsoil, or foundation beneath. A distinct line, nearly parallel with the surface, generally marks the depth of the upper soil, and separates it from the lower; and nearly the whole series of agricultural operations (draining and subsoil-ploughing being among the exceptions) relate to this surface-soil. The ingredients forming this soil are extremely varied; and it is part of the cultivator's business to study the effect of these components on the growth of different kinds of produce. There are various kinds of earths, such as clay, silica, lime, magnesia, and barytes; various metals, especially iron; alkalies, such as soda and potash; and many compounds resulting from the decomposition of animal and vegetable matters: all these are among the sum-total of ingredients constituting vegetable soil; and all exert their own peculiar effect in modifying growth. All those artificial applications which come under the general name of *manure* have for their object the modification of some or other of these components of the soil. The most valuable part of the soil is that to which the name of *humus* is applied, and which is a dark, unctuous, friable substance formed from the slow decay of animal and vegetable matter. Rich garden-mould and old neglected dunghills contain more of this fructifying agent than any other kind of soil.

The thickness of the soil and the declivity of the surface both exercise much influence on the growth of the crop. If the soil is thin, and supported by a sharp gravelly subsoil, it will become parched in dry weather: if supported by a wet clayey subsoil, it will be converted into mud by hard rain. So much influence is exerted by the angle of the surface, that a gentle declivity towards the south, and a shelter against cold winds, may make as great a difference as several degrees of latitude. The same soil, too, would produce very different results in different climates; each kind of soil being fitted for a certain average temperature and degree of moisture.

The quantity of humus generally determines the average quality of arable land. Thus, that which is most rich in this ingredient is best fitted for wheat; a lower proportion will suffice for barley; a still lower for oats; and the poorest of all will be suitable only for rye.

It is a feature in the growth of plants, likewise, that artificial soil or manure is found necessary to be added to the natural soil, not only in preparing it for the seed,

but also at stated intervals between the crops. The term *manure* is a very comprehensive one in husbandry; for every substance which is used to improve the natural soil, or to restore to it the fertility which is diminished by the crops annually carried away, is included under the general name. Some manures are used only to improve the mechanical texture of the soil; but the greater part of them act more directly in nourishing the plants growing in the soil. Lime is one of the extensive and valuable manures, being used in different forms and on soils of various kinds. The refuse of manufactures, consisting of earth, salts, and organic substances; soap-boilers' waste; the scrapings of horn, bone, and leather; the hair and wool of animals—all form manure. The ashes of burnt vegetable matter, sea-salt, and nitre, are likewise among the useful agents in this respect; and so also are ground bones. But animal refuse is the most valuable of all, and is that to which attention is now more frequently directed. The drainage of towns has long been regarded in many foreign countries as the most valuable of all sources, and is every year more and more so regarded in England. But perhaps the most remarkable, in a commercial point of view, is *guano*, the refuse of a bird found near the South American coast in the Atlantic. The refuse is found in large heaps on the island of Ichaboe, and forms the freightage for an immense number of ships sent out from Liverpool and Glasgow. Very recently it has been stated that more than a hundred ships have been anchored off the island at one time, taking in cargoes of guano, which are brought to England to be sold to the farmers as manure.—The whole subject of manuring land, especially since the writings of Liebig became known in England, is now looked upon as one of the highest importance pertaining to agriculture.

Draining.

All these are points which the agriculturist is required to study, and many others relating to the subsoil as well as the surface-soil. One extensive department of his art is that of *draining*, or removing from the soil any superfluous moisture that may lie in it. This involves three varieties: to drain land which is flooded, or rendered marshy by water coming over it from a higher level, and having no adequate outlet below; to drain land where springs rise to the surface, and where there are no natural channels for the escape of the water; and to drain land which is wet from the impervious nature of the subsoil, and where the evaporation is not sufficient to carry off all the water supplied by snow and rain. Different measures are adopted for these three varieties of the evil. The first requires all those extensive operations where large tracts of land are reclaimed by means of embankments, canals, sluices, and mills to raise the water; or where deep cuts or tunnels are made through hills, which formed a natural dam or barrier to the water. This involves the expenditure of a large capital, and is generally done by associations of persons on a large scale; the fens of Lincolnshire and the neighbouring counties have been, to a considerable degree, drained by these means; while in Holland whole provinces have been drained by similar agency—similar, at least, in a mechanical sense, but carried out by the government instead of by private individuals. The second kind of draining is of smaller extent but more general application; it consists in cutting a few drains or channels on the surface of the land, in such directions, and of such size, that the water which flows from springs, and which would otherwise saturate the surface-soil, is carried off to another quarter without being allowed to do this mischief. The third kind of draining is adopted when the subsoil is of so tenacious a character that the water from the surface-soil cannot find an outlet beneath, and consequently saturates the surface mould to an injurious degree. The remedy here consists in digging a deep furrow in the surface-soil, which shall reach down a considerable depth in the subsoil; and by covering this over, to prevent earth from falling into it, a subterraneous channel is formed, the direction of which is so chosen as to carry off the water from the spongy and over-saturated ground.

These are some of the preparatory matters to which the cultivator has to direct his attention; and then ensue the

Ploughing and Preparing for Seed.

The ground in its natural state, whatever may be its quality, is not fitted for the reception of seed without some kind of loosening, breaking, and arranging. The better the soil, the less is this preparation necessary; insomuch that where the land is very rich, there do we find cultivation most slovenly; whereas where it is less productive, more labour and skill are demanded and bestowed, to make up by art for natural deficiency. In the ruder stages of husbandry, the *spade*, the *hoe*, and the *rake* are the chief implements of this preparation; but the *plough* is the most efficient, and the most generally employed means. The object in view in using the plough is to cut up and turn over the surface-soil; and we will now see, by glancing at the construction of different kinds of ploughs, how this end is brought about.

The oldest form of the plough of which we have any record is that of a mere wedge, with a crooked handle to guide it, and a short beam by which it was drawn. The light Hindoo plough, used in many parts of India, differs very little from this form. There are certain technical names given to the parts of a plough, which must be understood before we can speak of their varieties. The *body* is that part to which all the rest is attached. The bottom of it is the *sole* or *slade*, to the fore part of which is affixed the *point* or *share*, the hind part of the sole being called the *heel*. The *beam*, which advances forward from the body, serves to keep the plough in its proper direction, and to the end of it are attached the oxen or horses by which it is drawn. Fixed in the beam in a vertical position, before the point of the share, with its point a little forward, is the *coulter*, which serves to cut a vertical section in the ground; while the point of the share, expanding into a *fin*, separates a slice by a horizontal cut from the subsoil or solid ground underneath. The *mould-board* or *turn-furrow* is placed obliquely behind the fin, to the right or left, in order to push aside and turn over the slice of earth which the coulter and share have cut off; it thus leaves a regular furrow wherever the plough has passed, which furrow is intended to be filled up by the slice cut off from the land by the side of it, when the plough returns. Wheels are comparatively a modern appendage to the plough, and are intended to support the end of the beam, to keep it at a proper level during the ploughing.

All the several parts have undergone improvements from time to time. The Roman plough (Fig. 36) consisted of a beam, a body, a share, and a handle or stilt; the office of the turn-furrow was performed by two pieces of wood, about six inches long, projecting obliquely upwards. The sole had two pieces of wood fixed to it on each side, forming an acute angle with it, in which the teeth were inserted. The teeth helped to push aside the earth to the right and left. A chain or pole, connected with the end of the beam, was hooked to the middle of the yoke on the neck of the oxen, and thus the plough went on making parallel furrows very near to each other.

The Anglo-Saxon plough (Fig. 37) is one of the earliest of which we have notice in our own country. In modern times the plough has been brought to the state represented by a few of the next following cuts. Thus, the Kentish "turn-wrist" or "turn-wrest" plough (Fig. 38) is one used extensively by the farmers of that county; it was planned for use in heavy soils, and is used with four horses in very stiff clays; but it has not undergone so many improvements as other forms of plough, insomuch that one horse power is often wasted by the bad construction of the machine. The Flemish plough, of which one form is shown in Fig. 39, has a small wheel *k*, by which the depth of the furrow is regulated; and a skim-coulter *i*, which pares off the grass and weeds, and turns them into the body of the furrow. As to the other letters of reference, *a* is the coulter, *b* the point of the share, *c* the mould-board, *d* the beam, and *h* the handles or stilts. Figs. 40 and 41 show two forms of plough used in the counties from which they are named. The Mole-plough (Fig. 42) is intended for grass-land lying low and wet on a tenacious subsoil, and is intended to cut very deep. The Subsoil-plough (Fig. 43) is one invented by Mr. Smith of Deanston for facilitating the drainage of land by cutting very deep furrows, penetrating several inches into the subsoil.

Such are some of the many forms which have been given to the plough, the object of all being to break up and loosen, and partly to overturn, the earth in which grain or other seeds are to be sown. This breaking up of the soil is aided by other machines, by some such a routine as the following:—After a harvest the plough is set to work, and the stubble ploughed in; the snow and frost of winter mellow the soil, while the stubble and weeds rot below; in spring, as soon as the weather permits, it is ploughed again, the first ridges being turned over as they were before, thereby completing the decomposition of the roots and weeds; it is then stirred up with the sharp points of a harrow, of which one form is shown in Fig. 44, by which the remaining roots are torn up; another ploughing and stirring follows at some interval, till the whole ground is mellow, pulverized, and free from weeds; manure is put in if required, and ploughed in, and the land is then prepared for the seed. For some light and porous soils a sort of artificial flooring between the surface-soil and the subsoil is produced by means of a machine called a *press-drill*. Sometimes, in order to lessen the use of the plough, an instrument called a *scarifier* is employed, so formed as to enter but a few inches into the ground, and to move a great surface by means of iron teeth peculiarly shaped. When the soil turned up by a plough is in large hard lumps, a *spiked* roller is sometimes used to break the clods.

It will thus be seen, without entering into the niceties of agricultural operations, that the larger and more important of the mechanical aids employed are destined to bring the surface-soil to a broken and pulverized state fit for the reception of the seed. Where, instead of being a field already cultivated, a piece of barren land is to be brought into cultivation, many mechanical operations are necessary, such as removing stones, trees, and shrubs, or in more favourable cases only the heath and coarse grasses which generally cover waste lands. One customary mode of effecting the latter of these operations is to cut a thin slice from the surface of the land, either by using a common plough with a very flat share, or by a more simple instrument worked by hand in the manner shown in Fig. 45. The sods thus cut off are dried and burned, by which insects and weeds are destroyed, and a valuable manure produced. When the new ground is very uneven, the holes are filled up and the hillocks levelled, either by the aid of the common shovel and wheel-barrow, or, as in Flanders, by an instrument called a *mollebart* (Fig. 46), consisting of a kind of wooden shovel drawn by a horse, and so dexterously managed by a man behind, that portions of earth are detached from one part, and deposited in another with great quickness.

Sowing.

Although by far the larger number of the mechanical aids have reference to the preparation of the land for the reception of the seed, even to the extent of employing steam-power for ploughing, yet the sowing itself has not been left without analogous improvements. There are different systems adopted in throwing the seed into the ground, of two of which the *dibble* and the *drill* are representatives. In "dibbling" (Fig. 47), a practice much followed in Norfolk and Suffolk, a man makes small holes at a distance of four or six inches, and in some nine or twelve inches asunder, with two rods about thirty inches long, one in each hand, the lower end of which is fitted to make a conical hole in the ground. In the holes thus made seeds are deposited by children, one in each hole; and a bush-harrow (Fig. 48) being drawn over the ground, the holes become filled in with loose earth. This mode of sowing is advantageous for the object in view; but it is so slow, and requires so many hands on a large farm, that attempts have been made to invent machines which should bore holes like the dibble, and deposit seed in each hole, much more quickly than by the hand-method. A very successful instrument of this kind was patented in 1841 by the late Rev. W. L. Rham, by which a great saving is made in the seed and in the labour of sowing, and by which the seed is deposited very regularly, and at equal depths.

Another method of sowing consists in scattering the seed as evenly as possible over the ploughed surface of the land, as the harrow follows and crumbles down the ridges, covering the seed which has fallen in the hollows between them. This is the "broad-cast" mode, and requires the utmost skill on the part of the sower in distributing the seed equally over the surface. The "drill" method differs from both. Instead of scattering the seed on the surface or in small holes, the principle of the "drill" husbandry is to deliver the seed by means of funnels, each corresponding to a small furrow made by a cutter placed immediately before the funnel. Some of the machines employed for this purpose are of very elaborate construction, and the following reference to the "Suffolk patent drill" (Fig. 49) will give an idea of the manner in which the required effect is brought about:—A, seed-box; B, a weight fixed to each coulter to press it into the ground, and to adapt it to all the inequalities of the soil; C, cylinder round which the coulter-chains are wound when the drill is moved from place to place; H, handles and racket-wheel, to prevent the chains unwinding; D, wheel turning the cylinder, which has the cups fixed to its circumference. When the drill is used, the box A is filled with seed, and the slide in it so adjusted as to supply it regularly; the lever G is raised, and the wheel D connected with the wheel E. As the horses proceed the cylinder turns, the cups take up the seed, and throw it into the funnels K K, which conduct it to the drill behind the coulter.

Without venturing to touch upon the relative merits of the different modes of sowing, let us next glance a little at the

Varieties of Corn.

In this country wheat, barley, oats, and rye are the chief varieties of grain; and by glancing at the next eight cuts we can see some of the features of difference between them: Figs. 50, 51, 52, being three kinds of wheat; Figs. 53, 54, 55, three kinds of barley; and Figs. 56 and 57, being the common oats and rye. Each figure gives the whole plant, and (except the last) also one "ear," from which the grain is derived.

It is curious to remark the changes of custom in England relative to the kind of corn used for bread. The Anglo-Saxon monks of St. Edmund, in the eighth century, ate barley bread, "because the income of the establishment would not admit of their feeding twice or thrice a day on wheaten bread." Piers Plowman, a satirical writer of the time of Edward III., says that "when the new corn began to be sold,"

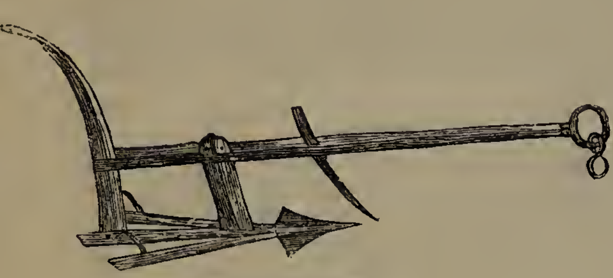
> "Woulde no beggar eat bread that in it *beanes* were,
> But of coket, and clemantyne, or else clene *wheate*."

In a valuation of Colchester, in 1296, almost every

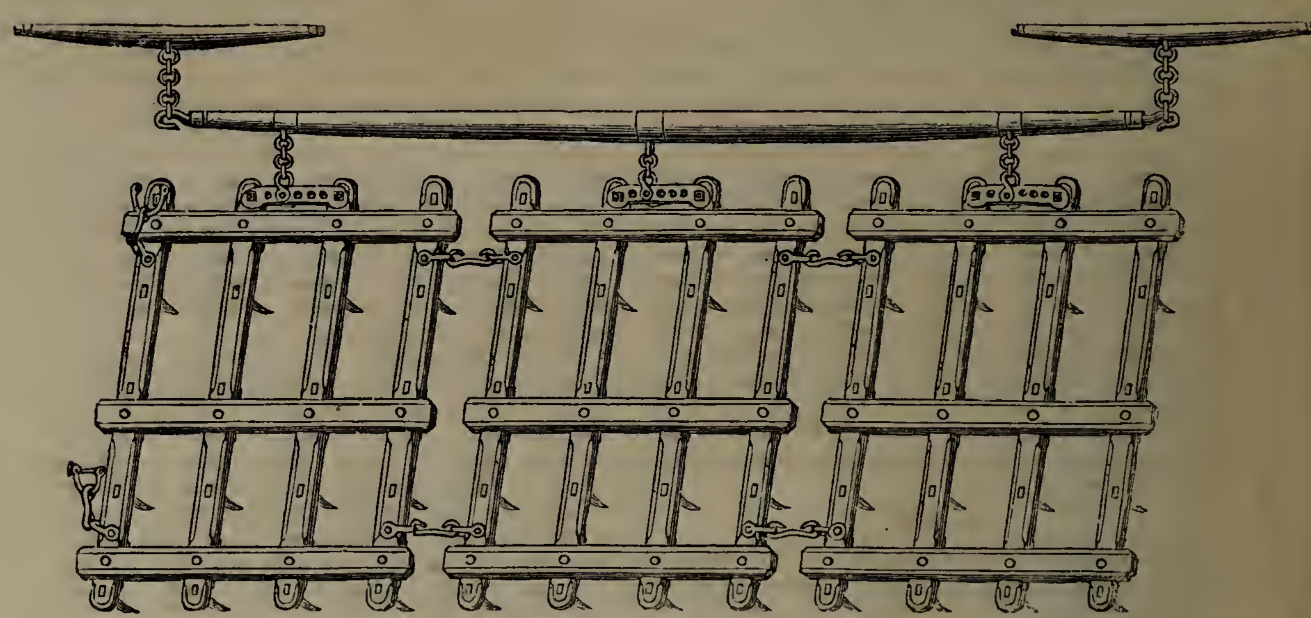
46.—Flemish "Mollebart," or Levelling Spade.

45.—Paring-iron.

47.—Dibbling, for Sowing Seed.

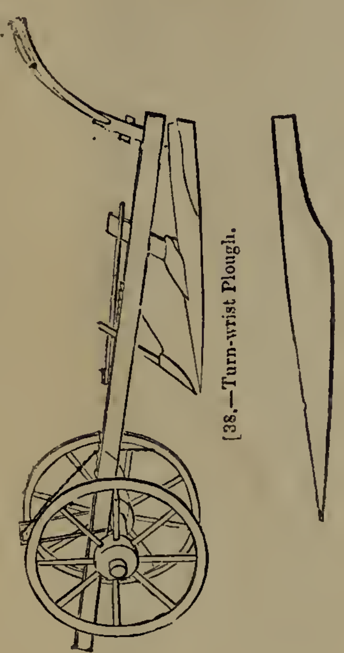


36.—Roman Plough.

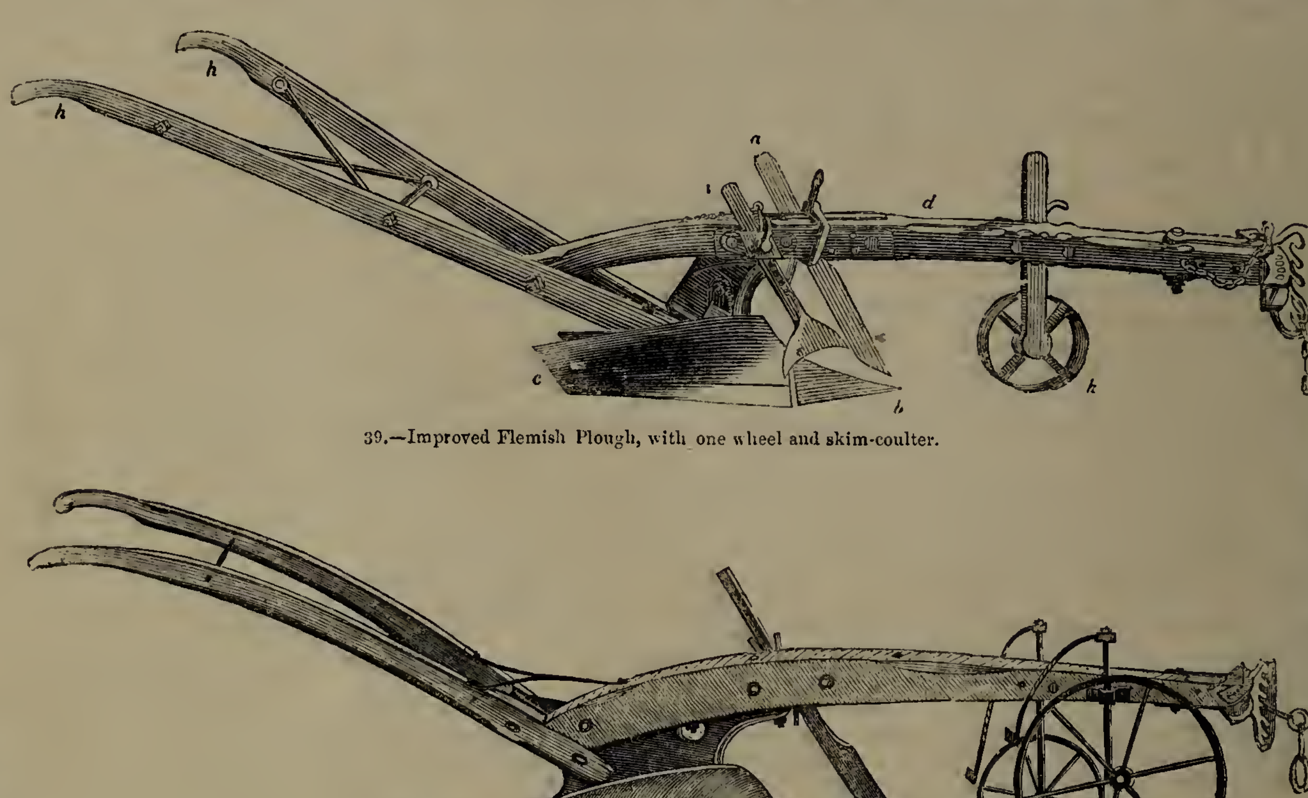


44.—Common Rhomboidal Harrow.

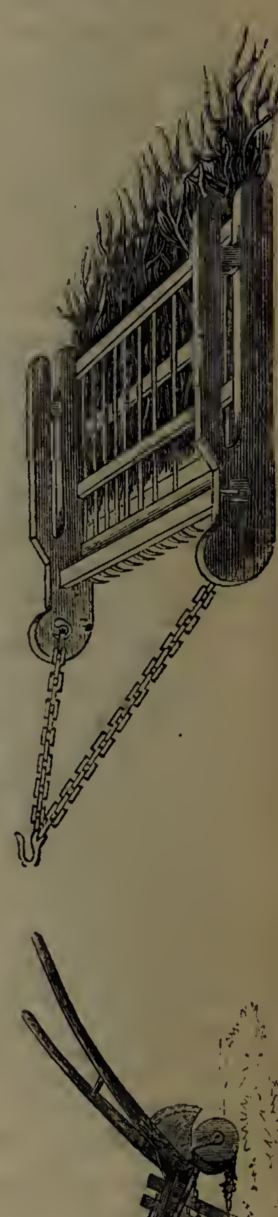
43.—Smith's Subsoil Plough.



38.—Turn-wrist Plough.



39.—Improved Flemish Plough, with one wheel and skim-coulter.

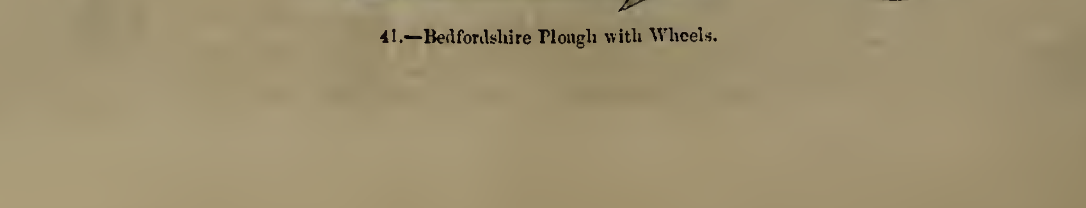


48.—Bush-Harrow.

40.—Ransom's Rutland Plough.

37.—Anglo-Saxon Plough. (Harleian MS. No. 4374.)

42.—Lambert's Mole Plough.



41.—Bedfordshire Plough with Wheels.

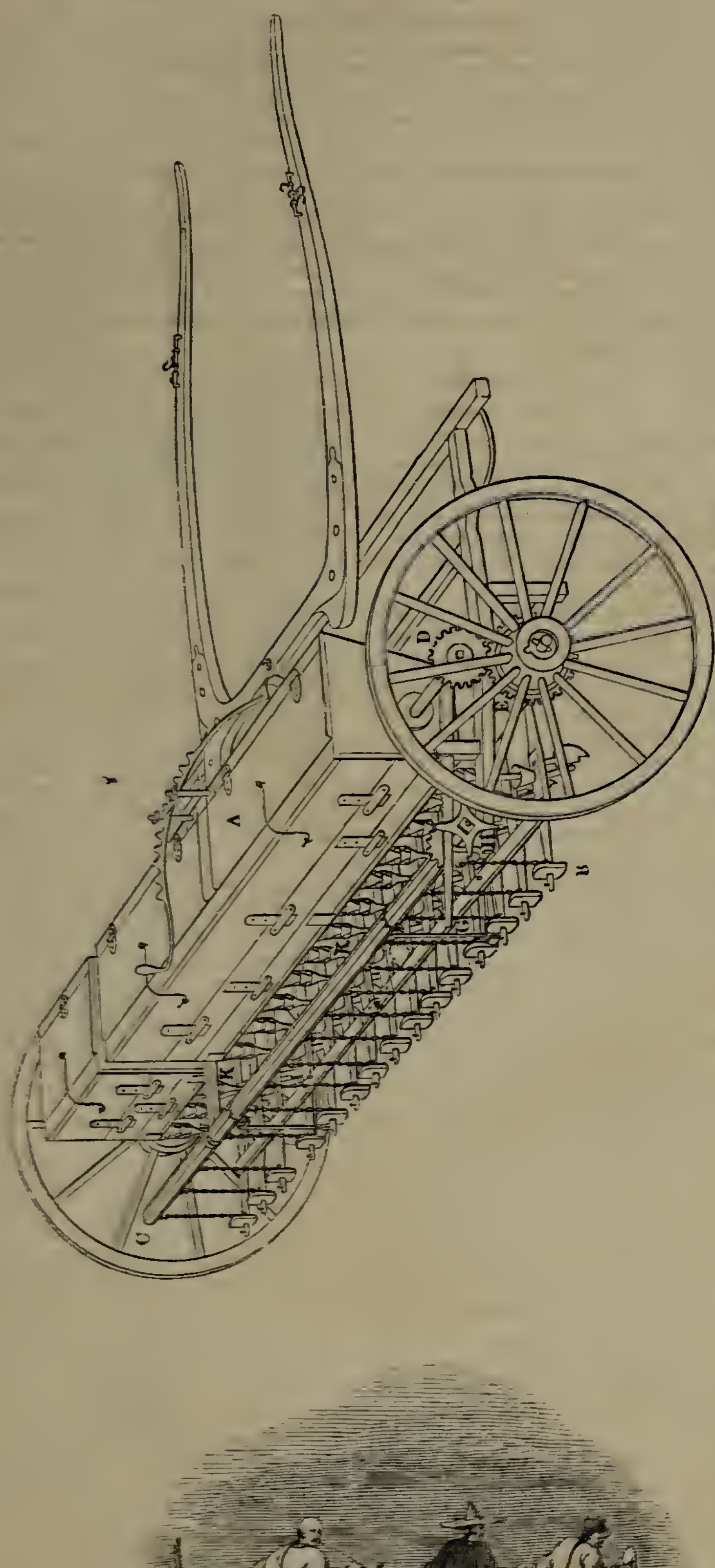
50.—Ear and Plant of Spring Wheat.

60.—Chinese Irrigation.

53.—Ear and Plant of Spring Barley.

51.—Ear and Plant of Winter Wheat.

54.—Ear and Plant of Winter Barley.



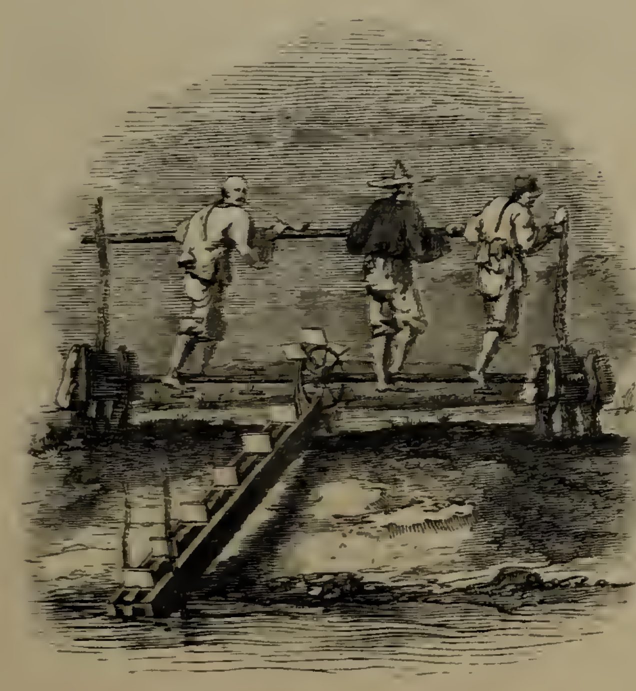
49.—Suffolk Patent Drill, for Sowing Seed.

52.—Ear and Plant of Egyptian Wheat

55.—Ear and Plant of Two-rowed Barley.

57.—Ear and Plant of Rye.

56.—Bearded Oats; Common Oats.



61.—Chinese Irrigation.

58.—Hoe.

59.—Hoe.

family was provided with a small store of barley and oats, usually about a quarter or two of each, scarcely any wheat being noticed in the inventory, and very little rye. About the beginning of the sixteenth century the suppression of the monasteries in England, and the discovery of the gold and silver mines of America, had much effect in the kind and price of the corn used by the poorer classes; and in the 'Reliques of Ancient Poetry' has been preserved a verse of a Somersetshire song of that period, bearing on one, or perhaps both of these points:—

"I 'll tell thee what, good vellowe;
Before the vriars went hence,
A bushel of the best wheate
Was zold for vourteen pence;
And vorty eggs a penny
That were both good and newe;
And this, I say, myself have seen,
And yet I am no Jewe."

The taste of the people about that period is indicated by the remark of Harrison, that "the bread throughout the land is made of such graine as the soil yieldeth; nevertheless the gentilitie commonlie provide themselves sufficienttie of wheate for their own tables, whilst their household and poore neighbours, in some shires, are inforced to content themselves with rie or barlie. And of the agricultural labourers he says, "As for wheaten bread, they eat it when they can reach unto the price of it; contenting themselves, in the mean time, with bread made of oates or barlie; a poor estate, God wot!" In the household-book of Sir Edward Coke, in 1596, there are repeated entries of "rie-meall, to make breade for the poore." In the time of Charles I. barley-bread was the usual diet of the humbler classes. Eden says that in about the year 1750 "so small was the quantity of wheat used in the county of Cumberland, that it was only a rich family that used a peck of wheat in the course of the year, and that was used at Christmas. The usual treat for a stranger was a thick oat-cake (called 'haver-bannock') and butter. An old labourer remarks that when he was a boy he was at Carlisle market with his father, and wishing to indulge himself with a penny loaf made of wheat-flour, he searched for it for some time, but could not procure a piece of wheaten bread at any shop in the town." The labourers of the southern and midland counties, in the latter part of the same century, began to rebel against the kind of bread given to them, which consisted of wheat, rye, and barley in equal proportions. With regard to the present century, Dr. Colquhoun made an estimate, thirty years ago (and the proportions might perhaps be applicable now), that of sixteen millions of persons in the United Kingdom, nine millions ate wheaten bread, four and a half millions oats, one and a half millions barley, half a million rye, and half a million peas and beans.

In foreign countries wheat does not form so large a proportion of the corn-bread as in England. England, France, parts of Scotland, Germany, and Hungary, and Western Asia, are the chief wheat countries. Rye is the common bread-corn in the sandy districts to the south of the Baltic and the Gulf of Finland; and the Swedish peasantry subsist very generally upon rye-cakes, which they bake only twice in the year, and which during most part of the time are consequently very hard. The other countries of Europe are guided in their choice of bread-corn by two circumstances,—the nature of the climate in respect to the growth of particular kinds, and the means of the people to purchase. By far the greater mass of the inhabitants of Europe, however, procure bread from one or other of these four kinds of grain. Of the substitutes for them in other regions we shall speak a few pages onward.

Irrigating the Crops.

All the minute details of management peculiar to each kind of corn form part of the husbandman's art: the thickness of the sown seed, the quality of the soil, the irrigation, the weeding, the loosening of the earth between the rows of plants—an operation in which the *hoe* (Figs. 58, 59) is the main instrument,—each process is guided by particular practical rules, according to the kind of grain. Of these, one of the most interesting in respect to the mechanical arrangements adopted is that relating to *irrigation*.

Every one knows the object of this process, and the general nature of the contrivances is pretty well known to most readers. Rivers, running streams, springs, and lakes or ponds, are made to diffuse their waters over a cultivated field when required by means of channels, dams, sluices, and other contrivances of a like kind, the two great processes of *drainage* and *irrigation* being in some respects complementary to each other.

It is instructive to compare the usages current in our own country with those in foreign lands, where hydraulic engineering is of a more simple character. Thus, the Chinese cultivated fields are irrigated in the two modes represented in Figs. 60, 61. In one of these, two men stand on opposite sides of a small stream, each holding a string by which a vessel is suspended over the middle of the stream; by slackening the cords, the vessel is made to dip into the water; by swinging them in a peculiar way it is filled with water; by tightening them the vessel is brought up to the level of the ground; and lastly, by jerking them, the vessel is made to pour out its contents on the neighbouring fields. The other method is more efficacious. There is a kind of quadrangular trunk extending obliquely upwards from a stream or pond to the field which is to be irrigated, and a number of square boards, just fitting the width and depth of this trunk, pass up through it when pulled by a chain, thereby forming a number of cells capable of holding water. Two or three men work a kind of tread-wheel, by which the chain is wound up, and in its progress the boards attached to it draw or carry up water from the lower to the higher level.

In Egypt there is a very curious system of irrigation adopted, called the *shadoof*. The apparatus consists of two posts or pillars of wood, or of mud and canes or rushes, about five feet in height by three feet apart, with a horizontal piece extending from top to top, to which is suspended a slender lever, formed of a branch of a tree, having at one end a weight chiefly composed of mud, and at the other, suspended from two long palm-sticks, a vessel in the form of a bowl, made of basket-work, or of a hoop and piece of woollen stuff or leather. Each lever being managed by a man, the bowl is made to dip into the stream, by whose side the apparatus is built up, and the water is thrown up to the height of about eight feet, into a trough hollowed out for its reception. When the height to which the water has to be raised is much greater than this, the *shadoof* assumes the more elaborate form represented in Fig. 62. It consists, in fact, of four or five shadoofs; the water is raised from the river by the bowls, and emptied into a trench or trough, from which it is taken by other bowls, and discharged into another trench above; and so on, from trench to trench, until it is raised to the level of the fields.

Reaping and Harvesting.

The industry bestowed by the husbandman is abundantly rewarded if a bright field of corn is the result of his varied labours. Then ensue two stages of operation, which, so far as they involve anything mechanical in their appliances, are the only ones which need here occupy us. These are the cutting down of the stalks or stems, and the extrication of the grain from the straw.

The reason for the peculiar character which harvest-time gives to country districts is thus stated by Mr. Rham:—"The reaping requires many hands to accomplish it in proper time, so that the corn which is ready for the sickle may not be too ripe and shed, nor the fair weather be allowed to pass before all the corn is secured in barns or stacks. The labourers who are required all the year for the common purposes of husbandry, seldom suffice for the harvest, especially on extensive farms; and recourse is usually had to the assistance of mechanics and artisans from the neighbouring towns and villages where the population is considerable, or labourers are induced by good wages to come from a distance. As the harvest is later in those parts of every country which have a more northern situation, or are higher above the level of the sea, bands of reapers from these come to assist in the harvest of those tracts whose produce is earlier. To encourage the annual return of so desirable assistants, every encouragement is given them, not only by wages, but also by food and drink, and amusements after the toil of the day. Thus the time of harvest is a time of rejoicing, both to the labourers and to the master."

The actual cutting of the corn is effected by the *reaping-hook* or *sickle*, one of the most ancient of all implements. In reaping with the sickle, a portion of the stems is collected with the left hand and held fast; while the sickle in the right hand is inserted below the left, taking the stems in its semicircular blade, and cutting them through by drawing the sickle so as to act as a saw, for which purpose the edge is finely serrated in a direction from the point to the handle. The heads of the corn, with the upper parts of the straw, are then laid on the ground in quantities which may readily be collected into a sheaf. The division of labour is introduced with advantage amongst a band of reapers. A certain number cut the corn, while others follow to gather the sheaves; some only preparing the bands, and others tying them, and setting up the sheaves into stooks or shocks, which usually consist of ten or twelve sheaves. The bands are made by taking two small handfuls of the cut corn, and crossing them just below the ears into a knot; the sheaf is then pressed with the knee, and the band drawn tightly around it; the ends are twisted together like a rope, and inserted under the band, which effectually fastens it.

Where the straw of the corn is not very valuable, the stems are cut at a certain height from the ground by the sickle; but where, as in the neighbourhood of large towns, straw fetches a good price, the stems are cut close to the ground, by means of a "fagging-hook," shaped somewhat midway between a scythe and a reaping-hook. It cuts the straw close to the ground by a stroke of the hand; and its curved form is useful in collecting stray stems, and holding a certain quantity of them between it and the left hand of the reaper when he makes up a sheaf. A certain quantity is cut towards the standing corn, the left hand pressing it down at the same time. When as much is thus cut as would make half a small sheaf, the reaper comes backwards, cutting in a direction at right angles to the first, and rolling together the two parts which he carries in the bend of his hook, and places on the band which has been prepared for him. A full-sized sheaf is usually composed of two cuttings; and two men will fully employ a third to make bands for them, tie up the sheaves, and set them up. It seems to be the opinion of scientific agriculturists, that this mode of cutting near the ground is more profitable in the end than the use of the reaping-hook, especially when an instrument called the Hainault scythe is employed; but that the ancient customs of the farmers oppose an obstacle to the general introduction of the method.

Many attempts have been made to introduce machinery for reaping corn, some of which are ingenious; but none have fully answered the purpose. The various inclinations at which the straws stand seem to be the chief cause of failure. Most of these attempted instruments have a revolving edge to cut the straw, and a drum or roller to lay the cut corn down regularly.

Then ensue the harvesting and threshing; processes which are conducted differently in different countries, according to the climate and other circumstances. In warm corn-growing countries the heat of the sun and air soon dries the straw, and hardens the grain, as they lie on the ground; and a spot being levelled on the field, the corn is threshed out immediately, either by the tread of cattle driven over it, or by the flails of numerous threshers; the threshed corn is winnowed and stored in granaries, and the straw is reserved till winter, when it forms the chief fodder of horses and cattle. But in colder climates, where the harvest is later, and cold rains and storms are frequent in autumn, the utmost danger is incurred by allowing the cut corn to remain on the ground; and consequently roomy barns are erected to secure it in the straw till it can be threshed. It was formerly always the practice in England to store the corn in barns directly it was cut; but the increase of produce, raised by an improved system of agriculture, gave rise to the practice of stacking corn in the open air, and securing it by a covering of thatch. It was soon found that the grain thus stored in the straw was better than that stored in barns; and the placing of pillars, for supporting the frames on which the grain is placed, keeps it dry, and secures it from the depredations of vermin.

How different is the mode in which the farmer brings his corn from the field to the barn in different countries! The English farmer has his waggon and horses all busily employed; one, perhaps, loading in the field, while another is on the road, and a third unloading at the barn; but in France, where the machinery of husbandry is not so complete as in England, the corn is carried by rough little horses guided by women (Fig. 63). In Normandy, it is said that seven horses and six persons are necessary to carry eight or ten acres of barley-crop in a day, half a mile distance, at a cost of about five shillings an acre. It is estimated, according to the average growth of crops in France, that one horse would have to make two hundred and thirty journeys to and fro, to carry the produce of ten acres; a task which an English farmer would effect in one day, and at much less expense.

Threshing.

Supposing the grain, of whatever kind it may be, has been brought to the barn, we may next trace it through the process of threshing. In foreign and more primitive countries the threshing is carried on in the open air by many singular means. For instance, in some parts of Italy and Greece the corn, after being cut with scythes, is carried immediately to threshing-floors, in the middle of the field, to be trodden upon by horses and asses (Fig. 64), which are driven round among them till the grain is separated from the ears. Another mode of employing horses (Fig. 65), adopted in Northern Africa, is to fix a strong post in the centre of the threshing-floor, with a moveable wooden ring at top, through which passes the cord that yokes the animals, and which can be lengthened or shortened at pleasure, so as to make them move round in a wider or narrower compass. In allusion to the practice of the Moors and Arabs, Shaw states, "Instead of beeves, they frequently make use of mules and horses, by tying by the neck three or four of them together, and whipping them afterwards round about the *nedders*, as they call the threshing-floors where the sheaves lie open and expanded, in the same manner as they are placed and prepared by us for threshing. This is indeed a much quicker way than ours, though less cleanly; for, as it is performed in the open air, upon any round level plot of ground, daubed over with cow-dung, to prevent, as much as possible, the earth, sand, or gravel from rising, a great quantity of these, notwithstanding this precaution, must be unavoidably taken up with the grain."

Oxen are employed in two or three different ways in the East for threshing. One of these methods is "by

the sledge" (Fig. 66). This is a sledge fixed upon two or three wooden rollers, armed with several iron rings with serrated edges, so sharp as to cut the straw. This machine, which is drawn by mules or asses, as well as by oxen, is easily driven by a man seated on the sledge; and, as it passes round in a circle over the corn spread beneath, the grain becomes trodden out, while the straw is chopped by the iron rings. Another Oriental mode is "by the drag" (Fig. 67). This is a strong frame of planks, or a large block of wood, armed and roughened at the bottom with flints or pieces of iron, and drawn by oxen, mules, or horses, over the corn-sheaves spread on the threshing-floor; the driver standing or sitting upon it according to its form. One variety of this kind was seen at work by Mr. Fellowes in Asia Minor; and he describes it as being "very primitive and curious, consisting of a thick plank of timber lying flat on the ground, with another smaller one inclining upwards, to which the animal is attached for the purpose of dragging it over the corn, which is spread out on the hard rocky ground; the flat underside is stuck full of flints or hard cutting stones, arranged in the form of the palate or rough tongue of the cow."

In the common English method of proceeding there is in the barn a threshing-floor, measuring perhaps twenty feet by twelve, paved with stone, brick, oak, or tempered earth. This floor is conveniently arranged with respect to the other parts of the barn. Mr. Rham sketches the following as being a good arrangement (Fig. 68). There is a passage for the waggons under the roof of the barn, where they can with ease and safety be unloaded; and if a threshing-machine is used, a floor raised about seven feet above the ground will contain the machine at one end and the unthreshed corn at the other; the part immediately under the machine receives the corn and straw after they are separated, and contains the winnowing-machine. According to this arrangement, A is the place for unloading the corn; B, the threshing-floor; C, the place of the threshing-machine; D, the lower chamber for receiving the corn and straw; E, the shed in which the horses work to move the machines; and F is a stable, or perhaps a store-room for agricultural implements.

In threshing by the flail, the corn is spread over the floor, and the flail being swung round the head, it is made to fall horizontally on the straw, by which the grain is beaten out: and by inserting the flail occasionally under the straw, it is turned over, and a fresh portion is brought up to be beaten. This work is so very laborious, that ingenuity has been exerted to devise a form of machinery for effecting it; and the following is the general system on which the machines now employed act:—A rapid motion is given to a hollow cylinder round a horizontal axis; on the outer surface there are projecting ribs parallel to the axis at equal distances from each other, the width of these being from two to six inches. Around half the cylinder is a case, the inner surface of which is lined with plates of cast-iron grooved in the direction of the axis. The ribs or beaters come quite close to these grooves, so that an ear of corn cannot well pass between them without being flattened. The sheaves of corn, having been untied, are spread on a slanting table, and in some machines are drawn in between two iron rollers, of which one is plain and the other fluted. The motion of these rollers is slow, while that of the cylinder or drum is very rapid. The beaters act on the straw as it comes through the rollers, and beat out most of the corn. But what remains is carried in between the beaters and the fluted case, and when it has made half a revolution all the grain has been beaten and rubbed out. It falls on a sieve, which lets the grain through, but retains the straw, which is raked off by hand or by circular rakes moved by machinery.

Without venturing to go beyond these slight details respecting the husbandry of corn, let us next follow the manufacturing history of the corn thus produced, and speak of

BREAD, AND ITS PREPARATION.

The miller's labours are now brought into requisition; and we shall see that the modes in which these labours have been made available in different times and countries are many and curious.

Mills and Corn-grinding.

Probably the very first mode of grinding corn was to place the grains on one stone, and strike or rub them with another. The pestle and mortar, or some kind of apparatus analogous to it, was very likely another form. To this, in all probability, succeeded the simple contrivance shown in Fig. 69, which is still in use among the Arabs. It can hardly be called a mill, for it bruises rather than grinds; but whatever we term it, it consists of a hollowed stone and a roller, which being brought into contact with the corn, reduces it into a coarse meal by means of rolling.

The hand-mill, or *quern*, in which one stone revolves on another, with the corn between them, is one of the most ancient and universal of mechanical implements. It has been used in very many countries, and from the earliest times. The allusions to it in the Bible are numerous, and illustrate in an interesting manner the customs of Oriental nations. The general character of them, without noting minor variations, is shown in Fig. 70, where *a* is the two stones, one on the other; *b*, the upper stone alone; and *c*, the lower stone alone. The concavity of the upper stone fits the convexity of the lower; and the corn, after being introduced at the central hole in the upper stone, rolls over the convex surface, and is ground in its passage. There is a spindle to connect the two stones, and a handle to the upper one, by which it is rotated. Such is the simplest form of the hand-mill, which has exhibited many varieties at different times. Dr. Clarke, when travelling through Nazareth, witnessed a scene which strikingly illustrated the Scripture passage concerning "two women grinding at a mill." There were two women seated on the ground, opposite to each other, holding between them two round flat stones; in the middle of the upper stone was a cavity for pouring in the corn; and by the side of this, near the rim, was an upright wooden handle for moving the stone. The operation began by one of the women, with her right hand, pushing this handle to the other woman opposite, who sent it round to her companion. By this means a circular and rather quick motion was communicated to the upper stone, while with their left hands the women supplied the mill with corn, to replace that which had been ground into flour.

Another stage is that in which an apparatus is used something like that employed by the Chinese for bruising rice (Fig. 71.). A large strong earthen vessel or hollow stone is fixed firmly in the ground, and the grain placed in it is struck with a heavy kind of mallet or pestle fixed to the end of a lever; the other end of the lever being worked by the foot of a man, who has before him a rail or bar by which to hold. Sometimes there is a kind of tread-wheel with many levers, worked by two or more men at once. The Roman mills, such as have been found at Pompeii, consisted of stones shaped conically, or rather like a bee-hive fitted one in another; and, being of heavy construction, they were worked by slaves.

Sometimes the hand-mill is provided with various appendages which increase its working power. Thus (Fig. 72). A is the upper stone, about twenty inches broad by five thick; B is the lower stone, fixed to the supporting frame-work; C is a cog-wheel, rotated by the handle D, and working in the spokes of a trundle F, fixed to the vertical axis G of the stones, the axis being firmly inserted in the upper stone at K; H is the hopper, into which the corn is put; I is a shoot or trough by which the corn is conveyed down gradually, through the hole K, into the aperture between the stones; L is an aperture at which the ground meal escapes after the operation is effected; and M and P are contrivances for increasing the distance between the stones to adapt them to particular kinds of grain.

The power of horses, of water, of wind, and of steam, have all been brought into requisition to aid in the grinding of corn; but whatever be the power employed, the grinding-surfaces are in almost all cases two heavy stones, the lower one fixed and the upper one revolving upon it. These surfaces are not quite smooth; they are grooved as in Fig. 73; the furrows being made in such relative directions that, when the two stones are placed one upon another, the channels cross each other like the two parts of a pair of scissors. Into these channels the flour passes after being pulverized by the action of the upper stone against the lower, and is forced out from between them at their circumference into the case by which they are surrounded. The whole of the details concerning the millstones is matter of much consideration to the miller. The choice of stone is the first point; "burr" stones from France, particular kinds from Wales, from the Peak of Derbyshire, from Ailsa Crag—all have their respective merits for particular purposes: the size is another point, for a stone may be either too small or too large to grind corn well; the number, angles, depths, and relative direction of the furrows on the surface, and the velocity with which the upper stone is made to rotate, are also points of import with those most nearly concerned.

It will be readily understood that whatever be the power employed, the efficient action is to cause the rotation of the axis to which the upper stone is attached; and therefore the mode in which a horse, a steam-engine, or a water-wheel may be made to yield this service will be readily conceived. With respect to a windmill, however, the action is somewhat peculiar, on account of the enormous arms or sails erected as a means to catch the wind. There are some windmills used on the Continent (Fig. 74) in which the sails bear a singular resemblance to those of a ship, being constructed altogether of materials capable of yielding to the varying force and direction of the wind; but the more common windmills are constructed of firmer and less yielding materials, such as meet the eye of most persons whoever walk into the country. That the turning of the mill-sails brings about the grinding of the corn is sufficiently well known; but it may not be amiss to show, by means of Fig. 75, what occurs between the sails and the millstones. In this view of the interior of the upper part of a windmill, the conical wall AB of the mill is terminated above by a wooden dome C, which is capable of revolving horizontally upon it. A ring EF of wood, forming the lower part of the dome, rests upon a ring GH of the same material at the top of the wall, and the surfaces in contact being made very smooth, the former may easily be turned round upon the latter, being prevented from sliding off by a rim which projects from it, as at K. Small wheels or rollers *a b d* are so put as to facilitate the revolution of the dome. The dome in turning carries with it the wind-sails MN, and their axle PQ; and this connexion enables the sails to be adjusted to suit the direction of the wind, the only object for which the dome is made to rotate; sometimes this is done by a man working a winch-handle below, but in general the wind itself is made to turn the dome, by means of a small auxiliary sail L, and connecting mechanism *m n p*. The sail-axle is supported at its inner extremity P by the top of the vertical shaft ST. The toothed wheel R revolves with the sails, and works into the toothed wheel S on the vertical shaft, setting the latter thereby into motion, and working the millstone which is fixed to the bottom of the shaft (not here shown).

Windmills, like most other specimens of constructive art, admit of the exhibition of taste and beauty, if the right talent is at hand at the right time. In an article in the 'Penny Magazine' (No. 300), on the means of cultivating popular taste, after alluding to the bald architecture exhibited by too many of our modern English buildings, it is said, "The windmill at Chesterton, Warwickshire (Fig. 76), is a striking instance of the application of superior art to what is considered a common-place object, but which is transformed by art into an object of interest. It is said to have been erected from a design by Inigo Jones; and no one will deem that his great talents were misapplied in conferring upon such a structure a character of fitness and propriety, resembling in effect, though not in kind, the greater works which are regarded among the triumphs of the art."

Bread and Baking.

It is so customary, so nearly universal, to pulverize corn into flour before using it in making bread, that the employment of some form or other of mill is observable in all civilized countries—in all countries, indeed, where corn is a common article of food. But beyond this point the differences are considerable, both in the kind of dough formed from the flour or meal, and in the arrangements for baking it.

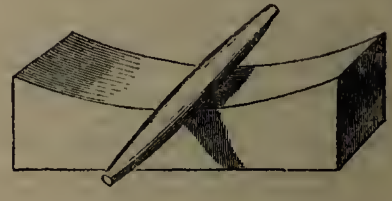
Let us take a London bakehouse as the centre of operations for making modern English bread; and see what are the implements and arrangements for carrying on this important work. A bakehouse in a complete state is usually provided with the following apparatus—a seasoning tub; a seasoning-sieve, pierced with holes; a wire-sieve; a pail, a bowl, and a spade; a salt-bin; a yeast-tub; a dough-knife; scales and weights; a scraper; four or five wooden shovels, with long handles, called "peels;" baking-tins; coarse thick flannels; a rasp; a scuttle or swabber for cleaning out the oven; "set-ups" (pieces of wood to keep the loaves in their places in the oven); a rooker and a hoe to serve as ash-shovels; a copper for boiling water; a few other minor appendages; and lastly, the most important of all, the *oven*. In former times, the baker was accustomed to place fuel in the oven itself, kindle it, allow it to burn away till the oven was well heated, then remove the ashes, and place the bread; but now the large bakehouses have a furnace or kiln by the side of the oven, by which a very equable heat is kept up, and at a lower expense than in the old method.

There is a very curious chemical process in the formation of bread, which leads to a distinction between *leavened* and *unleavened*, or *fermented* and *unfermented* bread. Biscuits, and many kinds of cakes and flat loaves, are unleavened; they have no *yeast* in their composition, and they assume a texture and flavour different from those of loaf-bread, as we generally find it. The broad features of this matter are simply as follows:—When flour is made into a paste or dough with water, and this dough is allowed to remain for some time in a moderately warm place, a partial decomposition takes place among the ingredients, whereby carbonic acid is generated; and the attempt of this gas to escape from the loaf gives rise to the commotion which is termed fermentation. It is found that bread baked from this fermented dough has a lightness which does not characterize other bread; and as wheat allows of this fermentation going on more favourably than oats or rye, bread made of the former becomes lighter and more porous than oaten or rye bread. To ferment the dough is, in reference to loaf bread, part of the baker's office; but the spontaneous fermentation would be too slow and incomplete for his purpose. He therefore brings it about by artificial means. A piece of old dough in a state of fermentation will induce rapid fermentation in a new mass; and this small piece, under the name of "leaven," is often used for this purpose. Again, the *yeast*, or frothy scum which rises on the surface of beer or ale during its fermentation, if added to recently made

65.—Threshing by Horses.

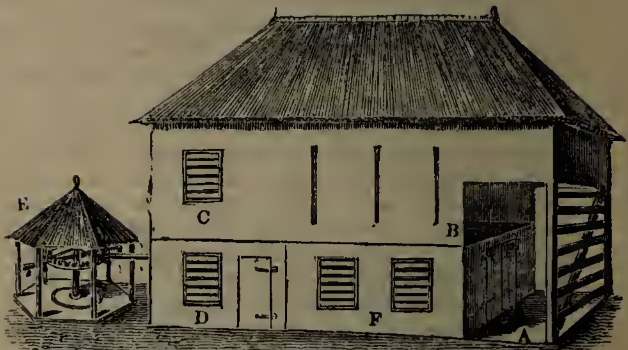
62.—Egyptian Shadoof, for Irrigation.

67.—Threshing by the Drag.



69.—Arab Corn-mill.

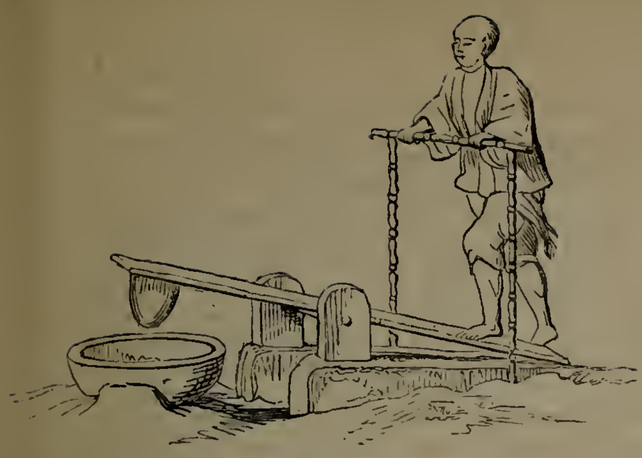
63.—Harvest in Normandy.



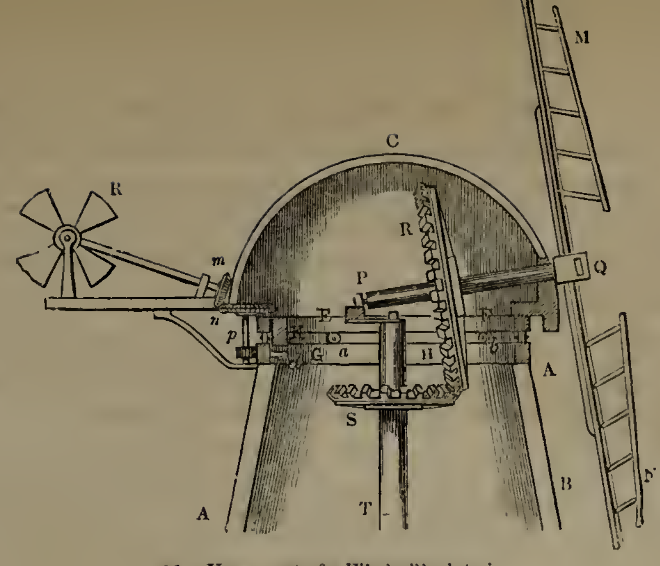
68.—Barn and Threshing-floor.

66.—Threshing by the Sledge.

64.—Threshing by Horses.

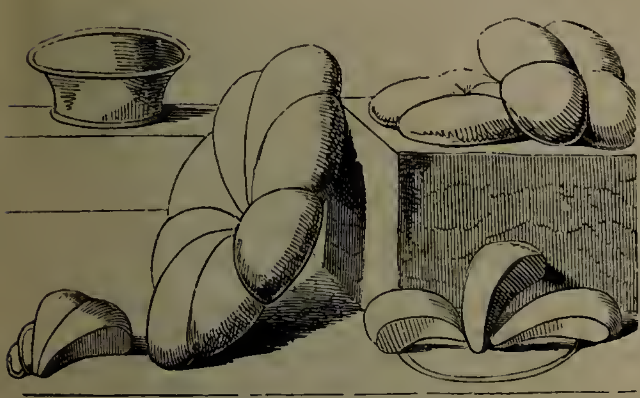


71.—Chinese Mill, or Pestle and Mortar.

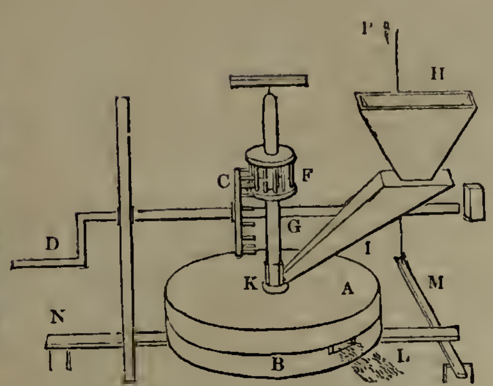


75.—Upper part of a Windmill; interior.

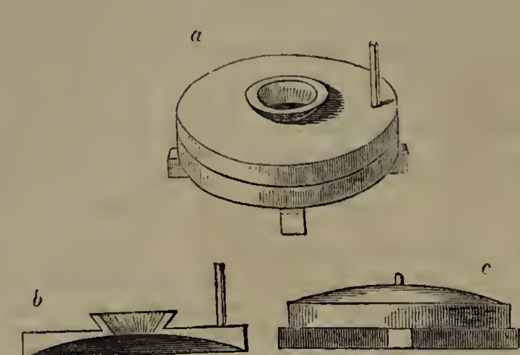
80.—Ear and Plant of Rice.



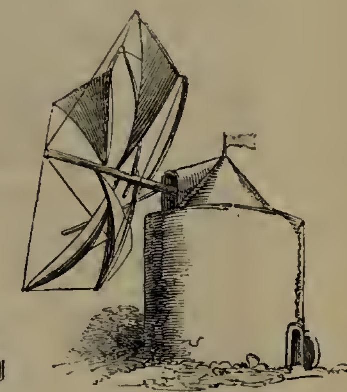
77.—Bread from Pompeii.



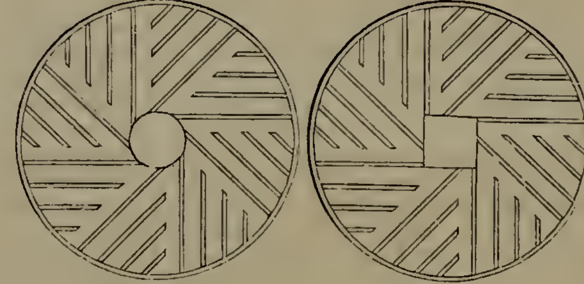
72.—Improved Handmill.



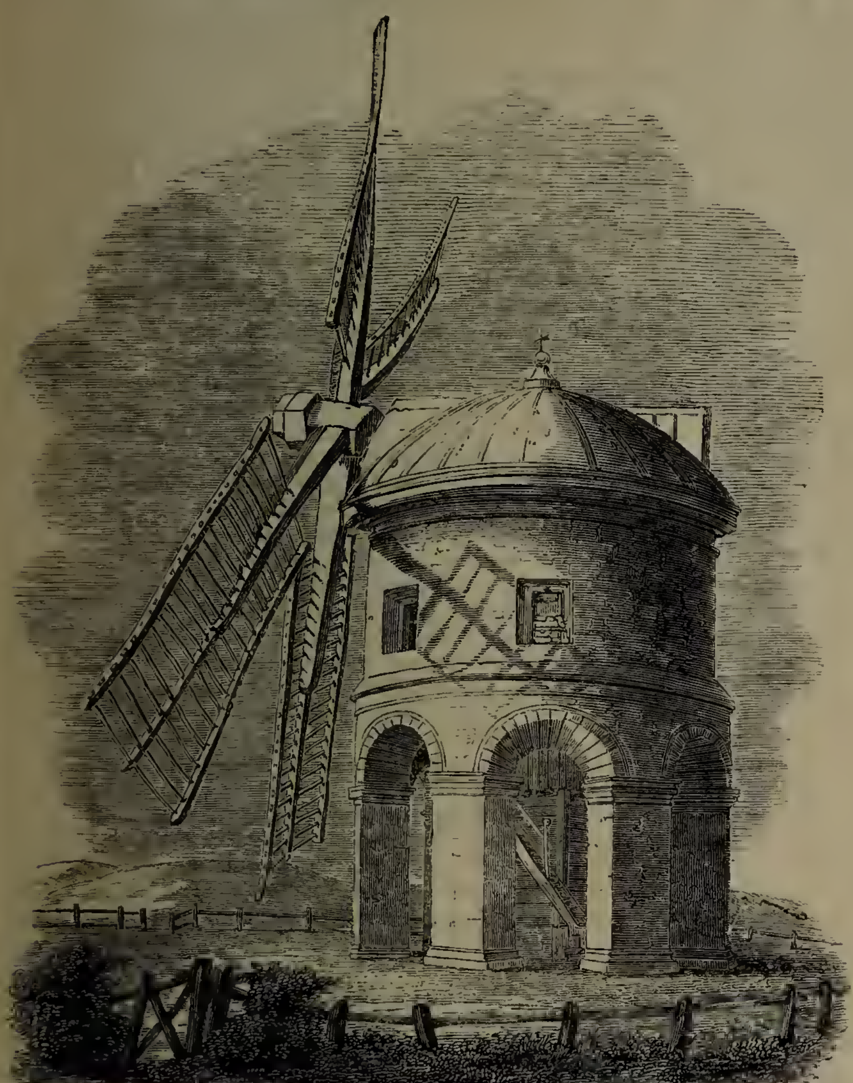
70.—Hand Corn-mill.



74.—Lisbon Windmill.

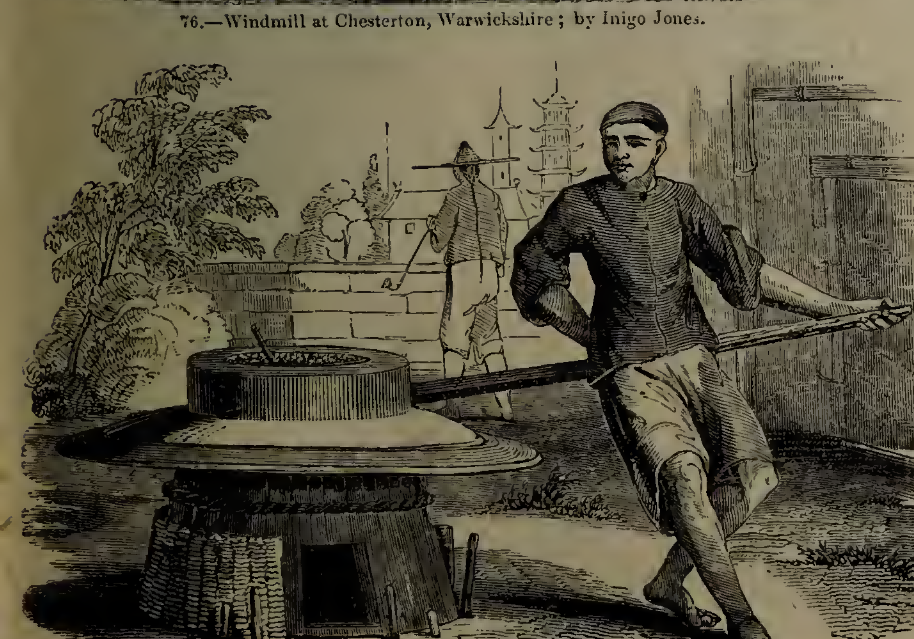


73.—The Grooves on Mill-stones.



76.—Windmill at Chesterton, Warwickshire; by Inigo Jones.

79.—Modern Oriental Baker.



81.—Chinese Rice-mill.

78.—Bread, from Pompeii.

dough, causes it to ferment more rapidly than leaven. In modern times yeast produced from potatoes has been occasionally employed; and so likewise have many kinds of artificial yeast. Generally speaking, these yeasts are made of ingredients somewhat intermediate between those of bread and of beer—such as flour and old yeast; flour, sugar, malt, and water; or malt, hops, and water; and the object is to produce a fermenting mass which, on being added to new dough, shall cause it to ferment also. The London bakers now very generally use a patent yeast, made from hops, malt, water, and old yeast, produced by boiling, straining, cooling, and other processes.

We will now appeal to the authority of the "*Baker*," in the 'Guide to Trade,' for the mode in which the London bakers at the present day generally make the "quartern and half-quartern" loaves with which we are all familiar. For a certain given quantity of bread, taken as a standard, about eight pounds of potatoes are boiled, and mashed in the mixing-tub. To these are added two or three quarts of water, about an equal quantity of patent yeast, and three or four pounds of flour; the whole mixture being stirred well together, and allowed to stand from six to twelve hours, at which time it will have become what the baker calls "ferment." Water is added to this, and well worked up with the hand till the mixture becomes liquid; and it is then strained through a sieve, to separate the skins of the potatoes. This liquid is poured upon one-fourth of a sack of flour in the trough, and mixed up well with it; flour is sprinkled on the top, and the mass is allowed to stand five or six hours. During this time it ferments and swells, and acquires a porous state, which procures for it the name of "sponge:" the carbonic acid forms and bursts through the adhesive mass; then it subsides, and again the swelling takes place. At a particular stage in this fermentation, three pailfuls of water, having a little salt dissolved in it, is poured upon the "sponge," and mixed up with it; and to the mixture is then added the remaining three-fourths of a sack of flour. When all the ingredients are thus combined, the dough is well worked up, and allowed to stand an hour or two to "prove." The mass is cut up, fashioned or shaped, and weighed into the form of loaves: the oven, which has been brought to the required heat, is "swabbed out," or cleaned, and otherwise prepared; and the loaves are ranged regularly in the oven by the aid of the long wooden shovels or peels; the square or cubical loaves close together in one part; the oblong loaves or "bricks" close together in another; and the "cottage" loaves separately.

In conducting these processes, the baker has to undergo an amount of heat, of confinement, and of broken sleep, which has but few parallels in the industrial arts, and of which we are but little aware when eating the fruit of his labours. At six o'clock in the morning he makes the "ferment" for next day's bread, after taking out his batch of hot baked loaves—then re-heats his oven a little for "rolls" and other small bread—then carries the hot baked bread into the shop—then returns to clean out the bakehouse and all its apparatus; attending to the rolls, &c., in the meantime. When all his neighbours are supplied with materials for *their* breakfast, he has *his* in the bakehouse (we are speaking of the journeyman baker). Very soon after this the "bakings" come in and occupy all his time till one o'clock; and after his own dinner he has about a couple of hours without doors, laden with his basket filled with bread. At about five o'clock in the afternoon commence the night operations, which occupy a large number of those hours devoted to sleep by other operatives. He "sets the sponge" and prepares the bakehouse; he sleeps for a few hours during the evening; he rises at eleven and commences making the dough, which takes him till some time after midnight; he heats and prepares the oven, and while the dough is "proving" he gets a little relaxation; he resumes the heavy and hot labours of making the loaves and placing them in the oven, and then catches about an hour's sleep, with the trough for a bed and a baking-tin for a pillow; this ended, he commences all the operations connected with the finished bread, and enters upon a new day. Sometimes there are two batches of bread baked in one day; and when, besides all this, we remember that Sunday is no day of rest to the baker except for a very few hours, we can appreciate the heaviness of his toil.

All the various stages in making and baking bread are subject to variety, and hence the different kinds of loaves which we may meet with in different parts of the country; but the general nature of fermented bread will be sufficiently seen from the above slight notice. As to the unfermented, common *biscuits* are the most familiar examples. They are formed of flour and water made very stiff, and not allowed to ferment at all. As to the fanciful varieties of "Abernethy," "butter," and other kinds of biscuits, they depend on some one or more additions to the plain flour and water. Biscuit-making is in one particular more of a *manufacture* than that of bread. Whoever has had an opportunity of seeing the magnificent ship-biscuit manufactory at the Deptford Dock-Yard, cannot fail to have been struck with the vastness and completeness of the arrangements. Steam-power grinds the corn, fills the troughs, mixes the flour and water, kneads the dough, flattens it into a layer, cuts it into hexagonal or six-sided pieces, stamps it with a device, and completes the manufacture up to the point where men place the biscuits in a range of large ovens. There are three of these Royal biscuit-establishments, at Deptford, Gosport, and Plymouth, at which *eight thousand tons* of biscuits can be made in a year, amounting in number to something like a hundred million biscuits!

Varieties of Corn-bread.

In different countries many variations of the mode of making bread are observable. Loaf-bread is seldom used in the northern parts of Europe and Asia, except by the wealthier classes. In Sweden, for instance, loaves are rarely if ever seen: rolls are to be had in the towns, but in the country districts rye-cakes are alone to be met with. In Westphalia a kind of very coarse black bread is made, of which the peasants bake one large loaf for the whole week; this is called "pumpernickel," and is divided for use with a saw. In many parts of Germany bread is made of grain nearly entire, or but just bruised; consequently very coarse in quality.

A curious memento of the art of baking among the Romans has been handed down to our times in the form of loaves of bread, found buried in the ruins of a baker's shop at Pompeii. These loaves, after lying eighteen centuries concealed from the light of day, were dug up in their original form (Figs. 77, 78), though of course as hard as a board. In all that respected the making and baking of bread, the Romans, in the height of their civilization, had attained a very respectable position. Their ovens were large, the varieties of bread many, and the regulations for governing the bread-trade, and preventing imposition on the poor, comprehensive and even perhaps over-elaborate.

It is a point of great interest in reference both to the Bible narrative and to domestic economy, to note the features of difference between the English and the Oriental modes of preparing and baking bread. Bread will not keep good longer than one day in a warm climate, and hence the baking is a daily process. When a guest is received hospitably at an Eastern house the bread is often kneaded and baked after his arrival; and this custom explains many passages in Scripture otherwise seemingly inconsistent. The editor of the 'Pictorial Bible' describes several different modes of making and baking bread practised at present in the East, and in all probability analogous to those followed in early times. According to one of these methods a fire is kindled upon the ground, and when the ground is sufficiently heated the fire is removed; the dough is next placed on the heated spot, covered with hot ashes and embers, and speedily baked. Another method resembles this, excepting that, instead of the bare ground or hearth, a circle of small stones is arranged, and these being heated, the paste is spread over them and then overlaid with hot cinders; the cakes thus baked are thinner than the former, and are used by the Arabs for their morning meal. A third method is rather curious: there is a circular pit dug in the earthen floor about three feet in diameter by four or five deep; hot embers are placed on the bottom of this pit, and the dough, brought to the form of large round or oval cakes, is dexterously thrown against the sides of the pit, which are smooth and clean, and are heated by the embers; here the cakes become soon baked through, and are removed just before they have a tendency to fall into the fire. Another method consists in the use of a circular earthenware pan or vessel for containing the fuel, the cake-dough being stuck against either the exterior or the interior of the sides of the vessel until baked; sometimes cakes are made as thin as a wafer by applying a soft paste to the heated surface of the pan, where it is baked almost instantly, and removed as a thin scale or film. Occasionally also an iron plate is laid over the open mouth of the vessel, and the bread baked upon that. Some of the wandering tribes make use of a slightly convex sheet of iron or copper, supported about nine inches from the ground on a few stones, and heated by a slow fire beneath; the cake-dough is laid on the plate, and quickly baked. The scene sketched in Fig. 79 approaches more nearly to the European method; it is followed in towns of some magnitude, where the population is sufficient to support bakers by trade; the master has his shop in the market-place, where he exposes his baked bread and cakes for sale, and behind is the oven where the baking is carried on, formed by a kind of recess in the wall, one half of which is occupied by the fuel and the other half by the cakes, which are baked in five minutes.

Substitutes for Corn-bread.

If we look around at the usages of different countries, especially those which have not reached the higher grades of civilization, we find that many modes are in use of producing a kind of bread, besides the baking of dough produced from the three or four sorts of corn which we have named. Bread is occasionally made, for example, of maize, of buck-wheat, of millet, of beans or peas, of potato, of chesnut, or of turnip; of sago, casava, plantain, banana, and other foreign plants; while rice, eaten simply as such, is perhaps the most important of all substitutes for bread. A few of these varieties may here fittingly occupy our attention.

Buck-wheat, though from its name apparently a variety of wheat, is not really so, it being a different kind of plant. The poor of some countries mix the meal of buck-wheat with a small proportion of wheat-flour, and make a kind of bread of the compound, which is however black and bitter, and deficient in nourishment. The plant is in fact nearly always cultivated as green fodder for cattle. Birds are fond of the seed; horses will take the seed in conjunction with oats; pigs will fatten upon the buck-wheat, and it is used at Dantzic to distil for fermented liquor; but as a food for man buck-wheat does not occupy the position which its name would seem to imply. *Maize*, or *Indian Corn*, is a plant approaching more nearly to our common notions, for it is used in vast quantities in America and Africa, where it grows, in the making of bread. Maize-bread is often made by kneading the maize-flour with a little salt and water into a stiff mass, rolling this out into thin cakes, and baking on a hot iron. Another kind of maize-cake, called *homminy* cake, is made by boiling Indian corn with a small portion of French beans, until the whole becomes a pulp, and this pulp being made into cakes is baked over hot embers.

Rice (Fig. 80) is one of the most valuable articles of food in the East. In a great part of India and China it forms the subsistence of the native population, more exclusively, and to a greater extent, than can perhaps be said of any other vegetable substance in any known region of the globe. It undergoes but little culinary preparation, being for the most part simply boiled with water, and eaten either by itself or accompanied by some oily or stimulating substance.

Rice is largely cultivated in America as well as in the East; the general mode of culture being some such as the following. A rice-ground is always swampy; at certain stages in the cultivation it looks more like a shallow lake than a field. The seed is sown in rows in the bottom of trenches, which are about eighteen inches apart, reckoning from the centres of the trenches; the seed is not scattered, but laid carefully in rows. Water is always at hand, kept back by flood-gates; and when the seed is sown, the water is allowed to overflow the ground to the depth of several inches, where it is allowed to remain about a week. The germination of the seed is promoted by this flooding, and the water being then drawn from the surface of the land, the plants sprout, rising in about four weeks to the height of three or four inches. At this time the flood-gates are again opened, the fields are once more overflowed, and remain in that state about sixteen days. The land is allowed after this to remain without further irrigation until the middle of July, being repeatedly hoed during the interval, and at this time water is again admitted, remaining on the surface until the grain is actually ripened. The harvest takes place in August and September, the reaping being performed by means of sickles. The alternate flooding and drying to which the rice-lands are subjected, render the cultivation an extremely unhealthy one.

From the rice-plants thus cut the grains are produced by some such processes of threshing and husking as corn; but as the husk adheres very closely to the grain, and as the rice is detached from the husk before being sent to market, much care is observed in removing the husk without breaking the grain. Thus the kind of foot-pestle before alluded to in Fig. 71 is employed by the Chinese for this purpose. The Chinese also use a kind of rice-mill (Fig. 81), worked by hand by means of a lever, but having two stones something like a corn-mill. The whole proceedings of this singular people, indeed, in respect to rice, are curious. Thus the *bowl* from which, and the *chopsticks* with which they eat their rice (Fig. 82), have been made the subject of the following description by Captain Laplace, in relation to a Chinese entertainment at which he was a guest:—"I found myself," says he "considerably at a loss how to use the two little ivory sticks, tipped with silver, which, together with a knife that had a long narrow and thin blade, formed the whole of my eating apparatus. I had great difficulty in seizing my prey in the midst of these several boats filled with gravy. In vain I tried to hold, in imitation of my host, this substitute for a fork between the thumb and the two first fingers of the right hand, for the cursed chopsticks slipped aside every moment, leaving behind them the unhappy little morsel which I coveted. It is true that the master of the house came to the relief of my inexperience (by which he was much entertained) with his two instruments, the extremities of which, a few moments before, had touched a mouth whence age and the use of snuff and tobacco had cruelly chased its good looks." Then came the rice. "I regarded with an air of considerable embarrassment the two little sticks with which, notwithstanding the experience acquired since the commencement of the repast, it seemed very doubtful

whether I should be able to eat my rice grain by grain, according to the belief of Europeans regarding the Chinese custom. I therefore waited until my host should begin, to follow his example, foreseeing that, on this new occasion, some fresh discovery would serve to relieve us from the truly ludicrous embarrassment which we all displayed. In a word, our two Chinese, cleverly joining the ends of their chopsticks, plunged them into the boats of rice, held up to the mouth, which was opened to its full extent; and thus easily shovelled in the rice, not by grains, but by handfuls."

Bread made of different kinds of grains and roots is, as we have before observed, generally a substitute for the better kinds which we can obtain in our own country. Thus *millet* (Fig. 83) is in some countries made into bread, which if eaten while warm, is said to be palatable, but which becomes dry and crumbly when cold. Pliny alludes to millet-bread as having been much in use among the peasantry of Italy in his time. The sago (Fig. 84) is made by the natives of Banda and Amboyna into bread in the following manner:—They saw the body of the tree into small pieces, and after beating and bruising them in a mortar, pour water upon the fragments; these are left for some hours undisturbed, to let the gritty farinaceous matter subside; the water is then poured off, and the meal, being properly dried, is formed into cakes, or fermented and made into bread, which is said to be nearly as palatable as wheaten bread. The Hottentots make a kind of bread from another species of sago-tree. The pith of this tree is collected, and tied up in dressed calf or sheep skin, and then buried in the ground for several weeks, by which it is rendered mellow and tender: it is then made into cakes, which are baked under hot embers. The "sago" of the shops is made from the pith of this tree, browned in colour by drying on hot stones, and granulated by passing through a sieve.

There is a kind of bread called *cassava*, made by the Indians of the Caribbee Islands. It is made from a very poisonous root, called *Jatropha Manihot* (Fig. 85), rendered wholesome by the extraction of its acrid juice. The root, after being washed, scraped clean, and grated in a tub, is enclosed in a sack made of rushes, of very loose texture; the sack being suspended upon a stick placed upon two wooden forks. A heavy vessel is suspended to the bottom of the sack, so contrived as to press the juice out of the roots. When the juice is all taken from the roots, the latter becomes a sort of starch, which is exposed to smoke in order to dry it, and when well dried it is passed through a sieve. The cassava, as the root is called when in this state, is baked into cakes by laying it on hot plates of iron, or on hot earth. The substance sold in the shops under the name of *tapioca* is a finer kind of cassava, made up in a peculiar way. In Brazil the cassava, under the name of *mandioca*, is prepared for exportation on a larger scale by the arrangements depicted in Fig. 86. The negroes in the front group are peeling the roots with a blunt knife; the two females on the left are washing the roots after peeling; the negro behind, working at a press, turns a wheel with one hand, and with the other presses the root against the mill-stones, between which it is drawn and reduced to pulp; this pulp is placed in the vessel from which the steam is seen to be rising, and there kept continually in agitation by stirring over a brisk and regular fire, until it becomes dry; it then assumes a granular appearance, is allowed gradually to cool, and is lastly packed in barrels. This mandioca-flour is either made into bread, or is eaten by the humbler classes just as it is, or mixed with some liquid.

The *yam* (Fig. 87) is another of the numerous roots to which the natives of tropical countries have recourse as a substitute for bread. It is a native of the East, where it grows very abundantly. The root is farinaceous, and somewhat resembles the potato, but closer in texture; and when either roasted or boiled, it yields a nutritious and good-flavoured food, largely eaten by the natives.

Besides all the many substitutes, of which the above are only a few examples, there are certain preparations of corn which assume a particular form of diet in different countries. One of the most remarkable of these is the *maccaroni* of Naples, a dish which is not only the principal food of the poorer classes, but a favourite food also with the wealthy. It is made from the "Grano duro," a small hard-grained wheat, cultivated for the purpose. The conversion of the meal, which is somewhat more coarsely ground than that intended for bread, into the long round strings called maccaroni, is thus effected:—The flour is mixed up with water into a paste, and this paste is kneaded thoroughly by means of a heavy block of wood, which beats into the trough where the paste is deposited. The block is attached to a beam acting as a lever, whose other extremity extends out eight or ten feet; and one or more men or boys, seating themselves outside at the further end of the lever, play at see-saw with the block at the nearer end, thereby causing it to fall heavily on the paste about to be kneaded—certainly a most awkward expenditure of muscular power, and not less odd than awkward. An eye-witness has remarked, "The effect produced on the eye of a stranger by a large manufactory where several of these machines, and a number of sturdy fellows, nearly naked and all bobbing up and down, are at work, has something exceedingly ludicrous in it;" and we may add that any one who visited the English biscuit-establishments as they were some years ago, would have seen a "bobbing up and down" not much less ludicrous. When the dough is kneaded, it is forced by simple pressure through a number of circular holes, the sizes of which determine the name given to the substance; the largest being *maccaroni*, the next size *vermicelli*, and the smallest *fedelini*. The hollow tube-like form of the maccaroni is thus produced:—Over each one of the larger holes meant for maccaroni, a small copper bridge is erected, which is sufficiently elevated to permit the dough to pass under it into the hole: from this bridge depends a copper wire, which goes right through the hole, and of course leaves hollow the dough that descends through the hole. When the paste has been thus forced through a workman takes up the maccaroni or vermicelli, and hangs it across a line to dry. From the long kneading it has received, and from the particular kind of wheat employed, the substance becomes very consistent, and dries in unbroken strings two or three yards long.

Besides these three forms, the Neapolitans make up wheat-dough into numerous others,—some long, narrow, and flat, like ribbons; some broad and thin, like sheets of paper; some round, like balls; and some like beans and peas. The cooking of the maccaroni, too, is equally diversified. Sometimes the long strings are boiled for a quarter of an hour, and served up with concentrated meat-gravy and finely grated cheese. Sometimes, when boiled, it is flavoured with butter, grated cheese, and tomata-sauce; but the poorer classes are delighted with it even if only boiled, or at best flavoured with a morsel of scraped cheese.

The streets of Naples exhibit many such scenes as that depicted in Fig. 88. The maccaroni-boiler and seller takes up his station wherever he can find room in the streets of the city; soon collecting around him a crowd of those who are happy enough to possess the means of purchasing some of the precious viand. His customers are not by any means particular about plates, knives, forks, or spoons; but employ such as nature gave. One favourite mode of eating the maccaroni is to take up a bundle of the long strings in the naked hand, and slide them down the upstretched throat without breaking them. For five *grani* (about twopence) the Neapolitan lazzarone can have as much of the luxury as will stay hunger; for ten grani he can have a sumptuous feast, including scraped cheese; for three grani more he can have a *carafa*, or bottle of common wine. All this seems to justify the motto put up over the maccaroni-stall, and which is somewhat equivalent to "Here you may eat well at small expense!"

DRINKS PROCURED FROM CORN.

It is obvious, from the sketch above given, that corn is the main variety of a large number of vegetable substances used in the preparation of bread, and that where corn (in the usual acceptation which we are in the habit of giving to this word) is not readily procurable, other parts of plants are prepared so as to approach as near as may be to the quality of corn. The few examples whereby these have been illustrated must be received merely as types of large classes, the more prominent features of which are given.

But before we leave the subject of corn, a little attention must be paid to that very remarkable property, whereby it is fitted for yielding beverages of a marked and decided character. Why it is that our fellow-men—in nearly all climes and in almost every grade in society—delight so much in some kind or other of fermented drink; by what steps this taste has grown up in different countries; and what are the opinions and the means for enforcing those opinions, concerning the necessity for tempering the propensity—are questions beyond our present scope; but as examples of art, modifying the natural qualities of a vegetable product, the preparation of *malt liquors*, of *spirits*, and of *vinegar*, from corn, must not be overlooked. It is, indeed, apart from any of the considerations here hinted at, a most singular circumstance, that the same grains of corn which we employ for bread may, by a different mode of preparation, be made to yield beer and ale; by a further modification, spirits; and by a still further stage, vinegar. The chemical transformations whereby this is brought about are somewhat complex in character; but it will serve to guide the ideas somewhat into the proper channel if we say that all grain (as well as some other vegetable products) contains starch; that this starch is more or less convertible into sugar; that this sugar may, by mashing or steeping, assume the state of *wort*, the basis for beer or ale; that this wort, instead of being made into beer by fermentation, may be distilled to yield spirit; or, instead of being distilled, it may be allowed to change its character, by further fermentation, from the sweetness of wort to the acidity of vinegar.

The general connection being thus seen, the mutual differences will be better understood.

Beer and Ale, and their ingredients.

The fermented sweet wort procured from corn does not assume the character of beer until other ingredients are added, the chief of which is *hop;* and there are two extensive series of commercial undertakings involved before the brewer commences his operations, viz. those concerning malt, and those relating to hops.

The grains of corn, in their hard and solid state, are not fitted to yield the saccharine principle which is to be fermented; but they are made, by artificial germination or malting, sweet and more soluble in water, from the conversion of the starch of the grains into sugar. *Barley* is the grain from which beer and ale are principally produced; and *malt* is the name given to the barley which has undergone this preparatory process. Each little grain, in the process of malting, is made to sprout out and germinate, as a necessary part of the operation. Sometimes barley, while growing, will sprout in this way; and the appearance of the ear in Fig. 89 will show how this sprouting affects the grains externally. In practice the grains are of course freed from the beard and other parts of the plant, and are made to germinate singly.

The trade of malting is a large and extensive one, and is carried on in roomy buildings. The barley is steeped in cold water for thirty or forty hours, whereby it imbibes water, increases in bulk, and emits carbonic acid. After this steeping the water is drained off, and the wet barley is thrown in a layer about sixteen inches deep, called a *couch*, on the malt-floor, where it remains about one day. It is turned over repeatedly, and the layer is gradually thinned or lessened in depth, during which a chemical process is going on, whereby the barley becomes heated, acquires an odour, exudes moisture, and sends forth little sprouts or germs. These sprouts appear at first like a small white prominence at the bottom of each seed, which soon divides itself into three rootlets, and increases rapidly in length. The rudiments of the future stem, called the acrospire, also begin to develop themselves; and at the same time the mealy or starchy part of the grain assumes a loose crumbling texture, arising from a change in the chemical condition of its ingredients. At a particular stage in the operation the maltster checks the further germination, by drying the barley in a kiln at a temperature of from 90° to 140°. By this change the barley becomes fitted to yield a sweet substance when in the hands of the brewer; and it now loses its former name to take up that of *malt.* Three different kinds of malt are made and used in brewing; one pale or amber, for yielding the fermentable extract; one brown, to impart a particular flavour; and one roasted or black, to give the dark colour which characterizes London porter.

Hop, the other main ingredient in beer and ale, does not require a manufacturing process like malt; but its commercial history is not less curious and interesting, arising from the speculative tone which pervades its sale and purchase. The hop is a plant of which the blossom only is used in brewing. It requires a rich soil, and its cultivation is attended with many hazards. After the planting, hoeing, weeding, stirring, and manuring, and when the young plants have sprung up to a height of about three inches from the ground, a number of supports or "hop-poles" are inserted in the ground. These poles are straight, slender shoots of willow, ash, or some other wood, from sixteen to twenty feet long; they are placed as thickly as the hop-plantation requires, and the young plants are tied to them with withered rushes, but so loosely as not to prevent them from easily advancing in their progress to the tops of the poles. When the plants have ascended out of reach upon the poles, persons go round with standing ladders and confine all the stray tops.

The planting takes place about February or March; the placing of the hop-poles occurs about April or May, and the gathering or harvest is in September. This gathering is a scene of great animation, from the number of persons employed, and the picturesque appearance which a hop-garden then presents (Fig. 90). Frames of wood are placed in some part of the garden or field where the hops are most forward: these are called bins or cribs, and consist merely of four pieces of board nailed to four posts or legs, the frame when made being about eight feet long, three broad, and three high. The poles with the plants are laid across the frame, and the "pickers" (six or eight women, boys, and girls) range themselves on either side of the frame, and carefully separate the blossoms from the leaves and stalks, dropping the former into a large cloth, hung all round withinside the frame on tenter-hooks. When the cloth is full the hops are emptied into a large sack, which is carried home, and the hops laid in a kiln to be dried; and so delicate is the hop in this particular that the kilns are kept heated night and day during the gathering season, in order that no time may be lost in drying after gathering. A good picker can separate eight or ten bushels of hops from the stems in the course of a day, generally amounting, after the storing and drying, to about a hundred weight. The hop-pickers come from Wales and some of the

82.—Chinese Rice-bowl and Chopsticks.

86.—Preparing of the Mandioca Root. (From a sketch in 'Voyage Pittoresque dans le Brésil, par M. Rugendas.')

85.—Indians preparing Cassava.

87.—Yam.

84.—Sago.

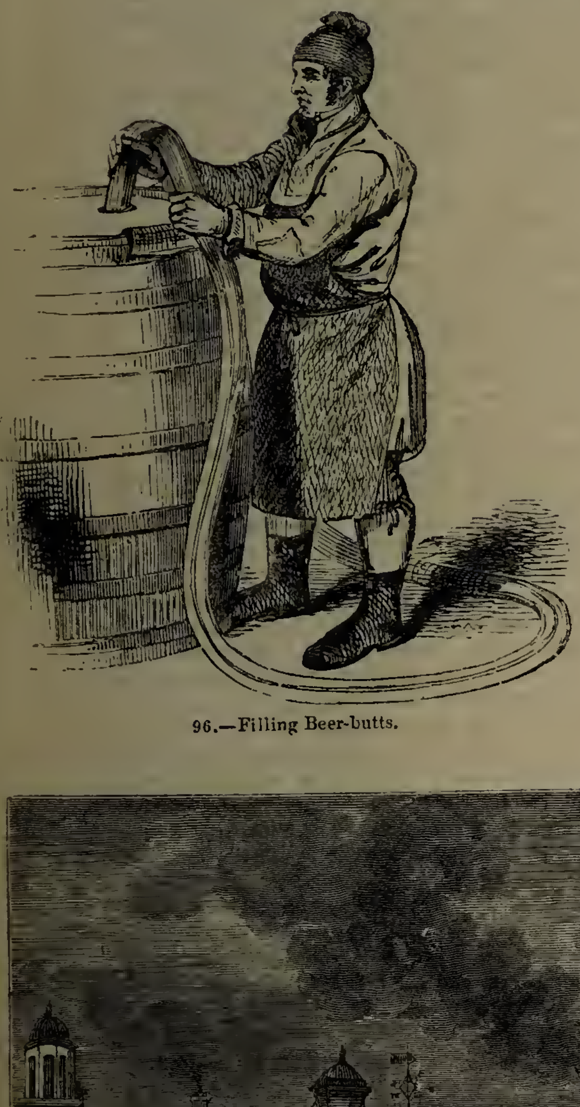
83.—Italian Millet.

88.—The Maccaroni-seller of Naples.

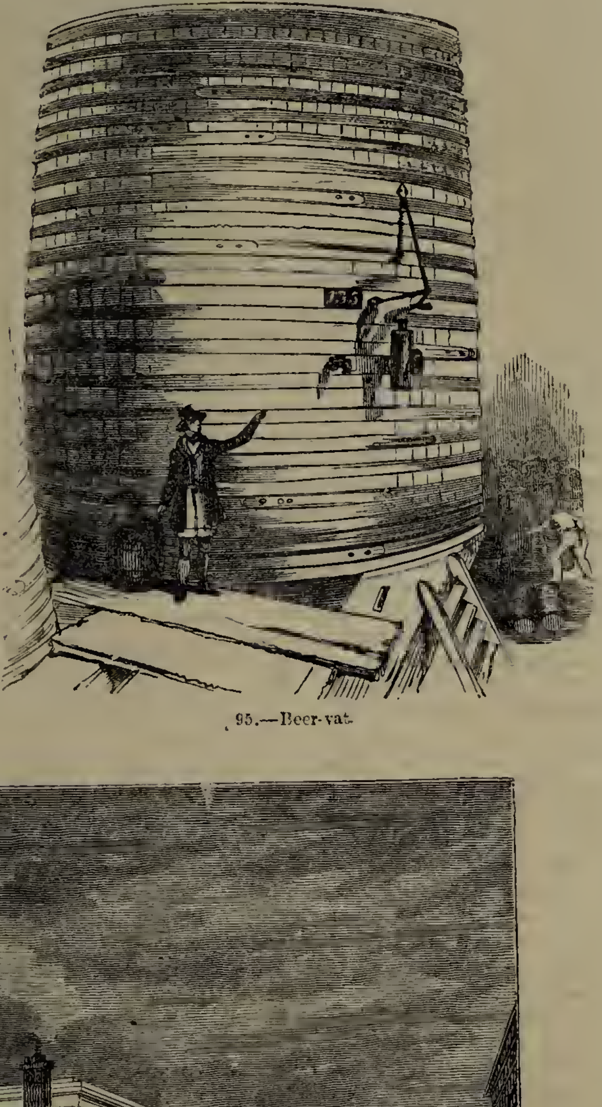
90.—Hop-Garden, Farnham, Surrey.

91.—Hop Queen. Hop-harvest Festival.

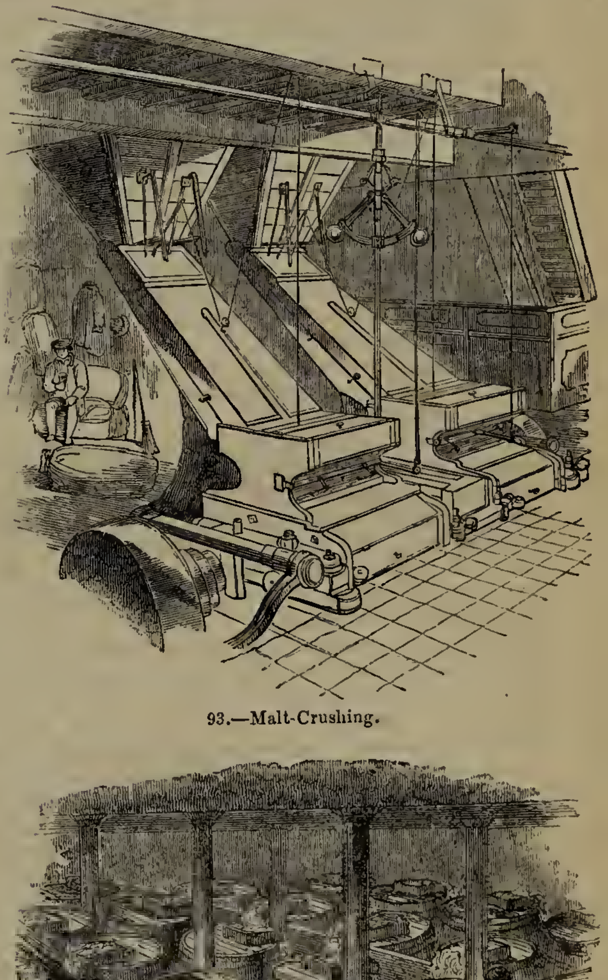
89.—Premature Germination of an Ear of Barley.



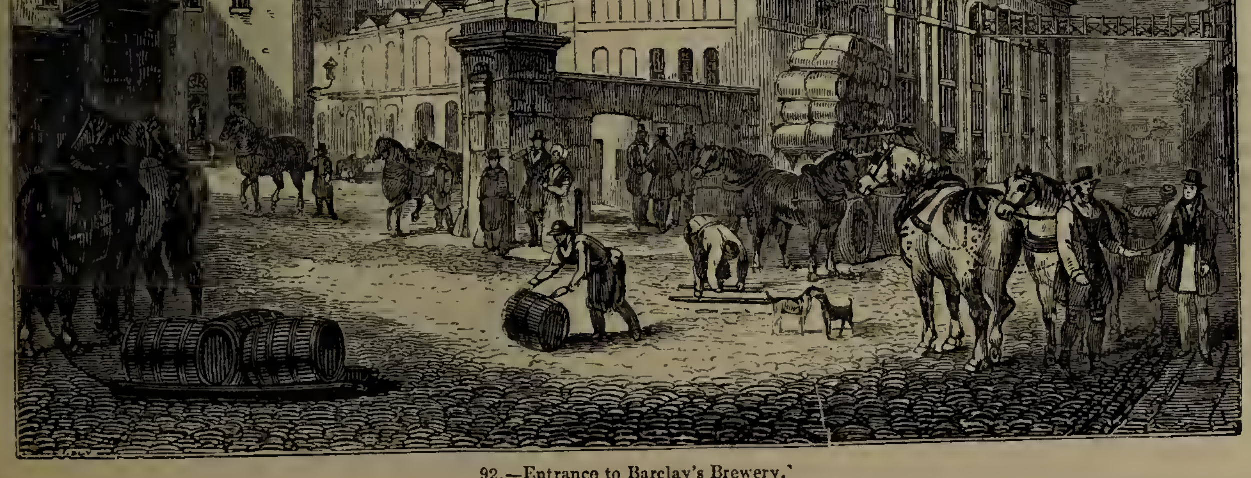
96.—Filling Beer-butts.



95.—Beer-vat.



93.—Malt-Crushing.



92.—Entrance to Barclay's Brewery.

94.—Working of Beer.

country parts of England, into Kent and Sussex, at the hopping season. There is a scene of great animation and industry while the gathering lasts, and when terminated, a merrymaking or hop harvest-home follows, in which one of the lasses is chosen to represent the "Hop-Queen" (Fig. 91) bedizened with ribbons and hop-blossoms.

When the hops are picked and dried, they are taken away from the kiln by a shovel, and stowed away in an adjoining room for five or six days; after which they are "bagged." This bagging consists in pressing the hops very tightly into bags or sacks. There is a hole in the floor of the stowage room, equal in dimensions to the mouth of a hop-bag; the bag to be filled is let down this hole, and suspended; one man throws hops into the bag; and another man, getting into the bag itself, presses them down with his feet, until the hops become pressed very closely into the bag.

The excitement among the hop-dealers both precedes and follows that among the hop-pickers. A speculator frequently buys a field of hops long before it can possibly be known whether the crop will be good or bad; and it is simply a matter of bargain and sale as to price given, for neither buyer nor seller can hit upon a really equitable price. Hence it arises that the losses or the gains are frequently enormous, scarcely any other commodity in general use having caused the gain or loss of such large fortunes in a given time. There is a fixed duty on hops, of something under a pound per hundred weight; and it has become usual to name the probable amount of duty, as an index to the quantity of produce in any given year. Thus, instead of saying that so many hundred weight will be produced, those interested in the matter name the amount of duty which they think will be collected; and this in itself seems to indicate the goodness or badness of the season. The plant is subject to so many diseases, and is liable to suffer from so many casualties, or from seemingly slight inadvertencies in the management, that the produce is subject to very great fluctuation: in some seasons the crop from one acre will amount to twenty hundred weight, while in others it will not exceed two or three; ten or twelve being considered about a fair average.

From the malt and the hops, then, thus brought to a marketable state, beer and ale are made; and there is scarcely anything else in England to equal in vastness the establishments where these beverages are made. The ten or twelve breweries at which London porter or "stout" is brewed are the giants of the whole; but some of the ale-breweries also are of vast extent. One establishment of this kind, perhaps the most celebrated in the kingdom, viz. Messrs. Barclay and Perkins', occupies no less than eight or nine acres of ground! The scene presented within its entrance-gates (Fig. 92) is most diversified and extensive. There are cisterns capable of supplying a hundred thousand gallons of water per day; steam-engines, to pump and grind, and perform other mechanical operations; malt-bins or boxes, twenty or thirty in number, and each as high as a moderate house; malt-warehouses and hop-warehouses occupying an enormous area; coppers, boilers, and vessels of vast size; vats capable of holding three or four thousand barrels each; thousands, and even tens of thousands of butts, barrels, puncheons, &c. In short, the scale on which matters are conducted in this and a few similar places, never fails to strike with astonishment those who have an opportunity of seeing them.

The chief points in the brewing of beer (which may be taken as an illustration of malt liquors generally) are as follow. The malt, dried and properly prepared by the maltster, is conveyed to the breweries in large sacks, and is there crushed or ground to the state of meal. This crushing is done in different ways, one of which is shown in Fig. 93, where the apparatus is so confined as to prevent the meal from flying about the room: the malt is crushed between a pair of steel rollers rotating nearly in contact, the fineness of the meal being made to depend on the kind of beer to be brewed. The crushed malt is conveyed to large wooden receptacles or "malt-cases," from which it descends into circular iron vessels called "mash-tuns." Hot water flows from a boiler into the mash-tuns, or rather into an open space between two bottoms to each tun, the upper one being perforated, and thus the water ascends the perforations and mixes with the malt. After this steeping has continued some time, and the water and malt have been well stirred up together, the water, containing a good deal of malt-extract, is pumped away from the malt, and conveyed into other vessels called "underbacks;" and from these again the liquor, now called *wort*, is pumped into the coppers where it is to be boiled. The malt is used two or three times over, and when its fermentable matter has been all extracted, the residue is sold as cattle-food under the name of *grains*.

It is while the wort is in the copper that the hops are added. The wort and the hops are boiled and constantly stirred for a certain length of time, and the whole contents of the copper descend into a perforated vessel, which retains the hops, but allows the liquor to pass. The hops are used two or three times, and are then sold for manure. From this perforated vessel or "hop-back" the wort flows into "coolers." These coolers are either cisterns of tubes through which cold water flows, and around which the wort cools; or they are extensive areas of flooring, sometimes amounting to as much as ten thousand square feet in one room, over which the hot wort is flowed in a layer five or six inches in depth, and where it soon cools by means of air entering from open windows at the sides.

The cooling being effected, the wort flows into very large fermenting vessels, where, being provided with a little yeast, it ferments, and gives off dense volumes of carbonic acid. The fermented wort, or *beer*, as it has now become, next passes into smaller vessels, ranged over the area of a large room (Fig. 94), and the froth or yeast which rises out of the bung-holes of these vessels is conveyed by small shoots or channels into a receptacle beneath. This working or "cleansing" of the beer is essential to its good quality, and when finished the beer is conveyed from these vessels into a large tank lined with Dutch tiles, whence it is conveyed to the store-vats, where it is deposited. As to these vats—when we state that there is one establishment where there are a hundred and fifty of them, holding on an average thirty thousand gallons each, and that Fig. 95 gives a correct idea of the size of the largest of them as compared with the height of a man—an idea may be formed of their appearance!

The beer is conveyed from these breweries to the public-houses in butts containing about a hundred gallons each, and the transference from these vats to the butts is effected by means of leather pipes or hose, one end of which is affixed to a cock or opening in the vat, and the other (Fig. 96) is inserted in the bung-hole of the cask, the latter being placed up endwise for this purpose. A very small quantity of "finings," consisting of isinglass and some other ingredients, is put into every butt of beer, to clarify and render it more transparent.

Of the various kinds of beer, porter, stout, ale, table-beer, &c., it will be needless here to point out the distinctions, since they depend on modifications more or less extensive of all the points pertaining to the qualities of the ingredients and the mode of brewing. Taking one with another, however, the consumption is so enormous as to constitute a matter of some moment in the commercial politics of the country. About *forty millions* of bushels of malt are brewed for beer annually in this country; and as the duty payable to the state on this quantity amounts to about five millions sterling, we have another instance, added to those adduced in our opening page, of the striking manner in which the revenue of a great kingdom is raised. We were before enabled to see that the "breakfast-table," or simply "*tea, coffee*, and *sugar*," furnish about a fifth of the national revenues; and if to these we add *tobacco*, with the malt for *beer*, and lastly *spirits* and *wine*, we find that these creature-comforts—praised or dispraised, nutritious or noxious, whichever we may deem any or all of them—actually yield considerably more than half the entire revenue of the state!

We are in the habit of thinking that Englishmen go pretty far in the beer-drinking custom; yet if we may credit the narratives of tourists, the Bavarians beat us hollow. Thus in Mr. Murray's 'Handbook for Southern Germany,' it is stated: "One of the characteristics of the Bavarian is his inordinate love for beer, to which he seems even more devoted than the natives of other parts of Germany. The moment the frontier is crossed, this devotion to beer becomes perceptible in the breweries in the great towns, where they are almost invariably the largest and most imposing buildings, and in the number of cellars and *guinguettes* in their environs, whither the citizens resort to drink. The conversation of the people constantly runs upon the amount and the quantity of the annual brewing; it is a subject of as important discussion as the vintage or harvest in other countries, or the state of the stocks at Paris or Frankfort. At the commencement of the season a surprising anxiety is everywhere manifested to discover where the best beer is to be had; and when ascertained, the favoured beer-shop becomes the constant place of resort till the supply is exhausted. A genuine beer-drinker will make nothing of swallowing ten measures (the measure holds nearly a quart English). Brewing is the most flourishing trade in Bavaria; it employs more than 5000 establishments, and nearly ninety-six million gallons are made annually."—p. 20.

Distillation of Spirit.

If it seems strange that beer and spirit and vinegar should all be obtained from one source, viz. corn, it will perhaps not appear less remarkable that one of these, spirit, is obtainable from such diverse sources as corn, potatoes, sugar, and fruit. Yet such is the case; and indeed there are many other kinds of vegetable produce which may be made available for the same object. The truth is, the chemical elements which form spirit are so closely allied in nature to those which constitute the main bulk of plants, that the transition from the one form to the other takes place under a great variety of circumstances.

It is the peculiar ardent principle, *alcohol*, which gives the general character to all kinds of spirit, the distinct qualities of each variety being dependent on the substance from which it is prepared, and the mode of preparation. Thus brandy, rum, whisky, hollands, gin, spirits of wine, cordials, and compounds, all owe their general properties to the alcohol which has been developed in them; but the variety of the sources is sufficient to account for the variety of flavours—French brandy being produced from wine (which is itself, of course, produced from fruit); West India rum from sugar or molasses: and British spirit, whether called by the names of British brandy, British rum, whisky, or gin, from corn. It is by means of berries, herbs, seeds, sugar, and other additions, that the fiery rawness of the spirit produced from corn is tempered down to a state more or less palatable.

As corn constitutes nearly the whole of the source whence spirit is obtained in England, the operation of making spirit divides itself into two branches, the *distiller* producing the spirit from the corn, and the *rectifier* bringing this spirit to a state fit for sale. The distilling itself, too, is a two-fold process; for in the first instance the corn is brewed so as to yield a sweet wort, something akin to that made by the brewer; and this wort is next subjected to a wholly distinct train of processes, comprising distillation properly so called. Hence one of the large distilleries (or "malt-distilleries," as they are called, to distinguish them from the smaller establishments where rectifying only is carried on) is necessarily a place of some extent, provided with vessels of great size, and various other appendages. There is but a very small number of these in England, of which six are in the vicinity of London. Fig. 97 will give an idea of the appearance of one of them.

The grain employed for distilling may be either malted or raw, as the distiller pleases, and he is guided partly by the state of the market as to which kind he uses. Malt being much more expensive, on account of the duty, than raw grain, he endeavours to lessen the proportion of it as much as he can: the proportion now employed by English distillers is generally about one part of malt to ten or twelve of raw grain, the raw grain being varying mixtures of wheat, barley, rye, and oats, according to the market price: but more than half of the entire ingredients is generally raw barley.

The production of sweet wort from the grain being a sort of brewing, is conducted in nearly the same manner. The grain is first ground, or rather, the raw grain is ground, but the malt is only crushed; and the two, when ready, are transferred to the "mash-tun" (Fig. 98), provided with a double bottom, and with an apparatus for stirring the contents. Hot water is allowed to flow into the vessel and to mix with the meal, from which it by degrees extracts the saccharine matter which gives the sweetness to *wort*. This mawkish, sickly liquor being prepared, it is allowed to flow into a cistern or "underback" beneath, from whence it is pumped up into the coolers, where it is cooled as rapidly as possible. We before alluded to the use of "cooling floors" in some breweries: the same are employed in some distilleries, and Fig. 99 will give an idea of their appearance.

As in the breweries, so in the distilleries, the wort, when cooled, is conveyed by pipes to the large fermenting vessels, where, being mixed with yeast, it is allowed to ferment. The nature of this fermentation is to convert the sugar of the sweet wort into alcohol; and according to the liquor about to be produced, whether beer or spirits, is this fermentation carried to a greater or lesser extent. The name of the liquor is now changed from "wort" to "wash," and it is by distillation that this wash is made to yield the spirit which has been developed in it. The "wash-stills" for effecting this (Fig. 100) are very large closed copper vessels, having certain openings to connect them with other vessels. There is a fire beneath the still, and the heat of this fire effects the separation of the alcohol somewhat in the following manner. The wash contains about ten or twelve parts of "proof spirit" in a hundred, this "proof" consisting of about equal parts of alcohol and of water: spirit evaporates or passes off in vapour at a lower temperature than water, and by keeping the heat at a certain point, *all* the spirit, with *some* of the water, passes out of the still in the state of a mixed vapour, leaving the remainder of the wash behind in the still.

The contents of the wash-still, now called "spent-wash," are emptied out, and used as a fattening food for pigs; while the weak alcoholic vapour passes out of the still into a "worm" or twisted pipe, which traverses a large vessel containing running water. By this arrangement the vapour becomes condensed into liquid, and is then called "low wines." The regulations of the English Excise prevent the distillation from being carried on as in France; but the French method, with many improvements suggested by Dr. Ure, may be understood from Figs. 101 to 105, in which Fig. 101 is the still; Fig. 102 the rectifier; Figs. 103, 104, the side view and the plan of the same rectifier; and Fig. 105 the refrigerator or cooler. The wash descends through a pipe OF in the rectifier.

and passes to and fro down a number of shelves or narrow trays D, till it reaches the bottom at C, where it flows through B into the still or alembic A, heated in the space R. The rectifier G contains water; and the frame of trays E has also water in its intermediate spaces I. H, K, L, M, N, O, are a series of contrivances for regulating the temperature of the rectifier and its contents. When the vapour has passed up from the heated still, through the complicated passages of the rectifier, into the refrigerator at K, it meets with a curious arrangement of pipes, consisting of an inner copper tube C, enclosed within an outer cast-iron one F. Cold water is admitted to the vacant space between the two pipes by means of the apparatus D, L, G, and flows *upwards*, while the alcoholic vapour flows through the inner tube *downwards*, whereby the vapour loses so much of its heat as to leave the tube at B in a liquid state. This complicated system is intended to make one distillation suffice, and to save time, labour, and fuel, in the whole process.

But to return to the common English method. After the "low wines" or weak spirit has left the worm or cooler, it passes through the curious apparatus seen in Fig. 106, where a man is enabled to test its strength by means of a hydrometer; since it is with especial regard to the strength of the spirit that the government duty is collected. This test having been from time to time applied, the "low wines" is conveyed to "spirit stills," where, by a further extension of the distilling process, it loses more and more of its water, and becomes stronger in respect to its alcoholic properties. Various qualities arise during these operations, to which the distillers give the odd names of "strong low wines," "weak low wines," "strong faints," and "weak faints;" but it will suffice to say, that, after a sort of contest between the distiller and the exciseman, as to which shall make the best bargain out of the quantity distilled—the spirit is brought to a burning and rough state, called "raw spirit."

According to the very stringent laws which now govern the spirit manufacture, no spirit must be *rectified* in the same building where it is *distilled*, or within a quarter of a mile of it. The distiller therefore sells his raw spirit to the rectifier, who brings it to one or other of the various saleable states. If "spirit of wine," so valuable for scientific and medicinal purposes, is required, the raw spirit is re-distilled, and brought to a state of great strength. If "British brandy" be the object in view, or "British rum," or "gin," or any of the various cordials or compounds, the crude spirit is re-distilled, accompanied by various berries and vegetable substances calculated to modify the taste, colour, and odour; and is brought to a degree of strength depending on its kind and price.

How far different the arrangements of the rude illicit "mountain still" of Scotland or Ireland are from this large manufacturing system, has been often sketched by some of our clever writers.

If *gin* be the characteristic form of spirit in England, and whisky in Ireland and Scotland, *brandy* is such in France. Brandy is the alcoholic portion of wine; and its name (derived from the German "brannt-wein," burnt wine) means wine which has been exposed to the action of fire. The name of brandy is also occasionally applied to the spirit produced from potatoes, carrots, fruit, and other vegetable substances; but that which is sold at a high price in England as brandy is always produced from wine. The French comprehend rum, arrack, geneva, malt spirit, &c., under the general name of *eau de vie* ("water of life," the same signification as the Irish "usque-baugh"); but brandy is the "eau de vie de vin." Brandy is made both from red and white wines; the stronger wines yielding the larger quantity of the spirit. Not only the wine itself, but the *marc*, or skins of the pressed grapes, is also used; although the spirit thus produced is much more acrid than that from the wine. The brandy when distilled is colourless, like other spirit; but it acquires a slight colour by age; and the colour with which we are familiar is purposely imparted to it by the addition of burnt sugar or of colouring matter. Many French towns, such as Bordeaux, Nantes, and Rochelle, export brandy in large quantity; but that from the town of Cognac, in the department of Charente, is deemed the best, owing to the care with which the ingredients are selected and the distillation conducted. Nearly half of all the brandy exported from France is said to be sent to England.

Rum is principally a West Indian product. It is procured from the sugar-cane, by the distillation of cane-juice, or from the skimmings of the juice from the boiling-house, or from the molasses or treacle, or from the "dunder" or lees of former distillations. It is an important point in the commercial economy of a West India sugar-plantation, that every refuse from the sugar-making itself is available for the production of rum, and that the one product as well as the other finds an immense market in England. In crystallizing or granulating sugar, there is (as we before explained) a certain portion of the juice which will not crystallize; and this portion, which constitutes *molasses*, amounts to sixty or eighty gallons to a cwt. of sugar. This molasses forms the material for the best rum; a gallon of the one being able to yield a gallon of the other. The process of distillation is analogous in principle to that adopted for other kinds of spirit. Like as in the case of brandy, the English rectifiers have succeeded in forming a market for imitative rum, made from English spirit, and flavoured artificially so as to resemble as near as possible the produce of the West Indies. From these and other causes, the consumption of West India rum in this country is much smaller than it was some years ago.

Wherever our tourists and travellers bend their steps, they are pretty sure to meet with indications of some kind of distillation being carried on, for the sake of making a spirituous drink. Sometimes it is from turnips, or potatoes, or some other kind of root; sometimes from seeds, from leaves, from the exuded sap; in short, be it for good or evil, this taste seems to have spread very extensively. Many juices of plants acquire the stimulating or intoxicating quality without the process of distillation. Thus, the *Areng Saccharifera* (Fig. 107) is a tree from which the inhabitants of the Indian Archipelago procure one of their beverages. The sap flows in great abundance from the wounded branches about the time when the fruit is forming; a bamboo bottle is tied to the extremity of an amputated branch, and removed twice a day, morning and evening; and the sap thus produced, which is at first transparent and something like new wine, becomes in time yellowish in colour, powerfully odorous, very astringent, and intoxicating: but when taken in moderation, it is said to be stomachic and wholesome. Another variety is the *pulque*, which the Mexicans prepare from the *agave* (Fig. 108). The agave plants are cultivated almost wholly for their juice; and at about the age of five or six years, this juice is ready for collecting. The Mexicans cut the bundle of central leaves of the plant, and enlarge the wound, covering it with lateral leaves, which they raise by drawing them close, and tying them at the extremities. In this wound the juice seems to collect from the plant generally, forming a true vegetable spring that keeps running for two or three months, and from which the cultivator draws three or four times a day. One plant commonly yields eight pints in twenty-four hours; and some have been known to yield seven quarts per day, for four months. This juice contains a great deal of sugar and mucilage, and when allowed to ferment it produces the pulque, a vinous beverage with an extremely disagreeable odour, but stomachic and nutritive qualities. A very strong brandy is also made from it.

The distillation of spirit from roots will be sufficiently illustrated by what Mr. Laing, in his 'Residence in Norway,' tells us of the Norwegian method. "I went," says he, "to see the process of distilling brandy from potatoes in a small work at Drontheim. The potatoes are first washed quite clean, then steamed, and crushed between two cylinders. They are then in the state of pulp or soup; which is run off into vats to ferment along with a small proportion of malt. I found that in eight barrels of potatoes, equal to four imperial quarters, they used in this distillery two *vogs*, equal to seventy-two pounds weight, of good malt. The fermentation requires generally three days, and is produced by yeast; the process then goes on as in our stills. The produce from this quantity of potatoes and malt varies much, according to the quality of the former. From eight to twelve, and even sixteen pots, each pot four-fifteenths of a gallon, is the usual return from one ton or barrel, viz., half a quarter of potatoes. Every farmer is entitled to distil the produce of his own farm; and pays a trifling licence duty, if he buys potatoes and distils as a trader. A still is kept on every farm, not merely for the sake of the spirit, of which the consumption in a family is very great, but for the refuse or wash to the cattle. The spirit is distilled twice for the use of the family, and flavoured with aniseed. It is strong and fiery, but not harsh or ill-tasted. What has been only once distilled has not so raw and unpleasant a taste as new whisky. The Norwegian gentry seem to prefer it as a dram, when twice distilled, to Cognac brandy."

Vinegar, from Corn or Fruit.

Vinegar, like spirit, can be produced both from corn and from fruit, or rather from wine; and, also like it, the English manufacturers are accustomed to adopt the corn method, and the French the wine method.

The malt-vinegar manufacture involves the *brewing* incidental to the beer and the spirit manufactures, carried to a particular stage suitable to the object in view. The malt is in the first instance ground, or rather crushed; and is then "mashed" in circular mash-tuns, with water, the mixture being kept constantly stirred. As the temperature of the water is an important point, in respect to the mashing of malt for vinegar, there is at one of the large vinegar works a contrivance at the top of the copper or boiler (Fig. 109) whereby a balance-weight indicates on a graduated scale the depth of water in the boiler, and a hole allows a man to test the temperature of the water by means of a barometer.

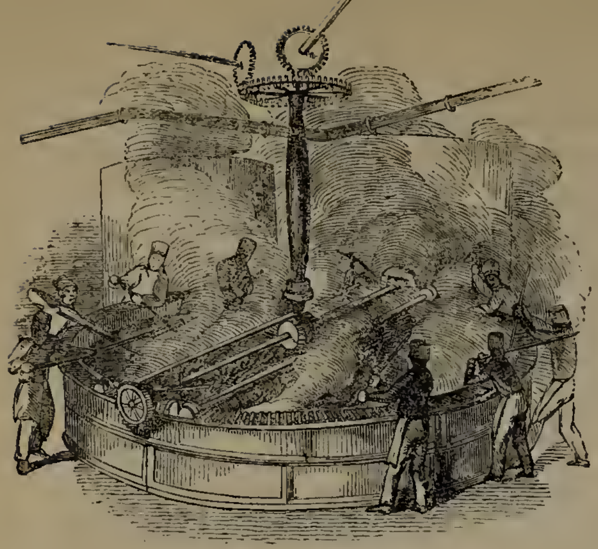
The *wort* being extracted from the malt, is allowed to flow into a cistern, and is then pumped up into a cooler or refrigerator. We have shown one of the "cooling floors" sometimes employed; and Fig. 110 will show one form of the refrigerator. This vessel is so arranged, by means of pipes within it, that a constant current of hot wort is flowing through it from west to east. The quantity and velocity of each flow are so adjusted, that the water cools the wort by the time that the latter has passed through the vessel. After the cooling, the wort flows into fermenting-tuns, where it undergoes fermentation pretty much in the same way as the wort for beer or spirits, but to a different degree: and the fermented liquor, which the distiller calls "wash," is designated "gyle" by the vinegar-maker.

Beyond this point, the manufacture of vinegar departs from that of beer or spirit. Instead of being boiled with hops like the former, or distilled like the latter, it is allowed to go through a slow spontaneous fermentation which changes the alcohol into vinegar This transformation is brought about in two very different ways. In the one case, casks containing the gyle are placed in close rooms heated to a high temperature; in the other they are arranged in rows in an open field, where they remain many months. In both cases the gyle is converted into vinegar, principally through the agency of heat in the first method, and that of the oxygen of the air in the second. When the vinegar is to be acetified in the field, it is made during the three spring months, and then left several months in the field. Many circumstances are involved in the consideration of the relative advantages of these two methods; but the "stoving" method is more generally adopted in France, while the "fielding" is the customary mode in England. In the former of these two methods, the casks containing the gyle are arranged conveniently in stove-rooms, which are closed and locked, and then exposed to a certain temperature till the acetification has been wrought. During this process, a suffocating acetous vapour fills the stove-rooms, and no one can support or stay in the rooms beyond a few minutes.

The "fielding" is a very different matter. The casks, each of which contains about a hundred gallons, are ranged in long parallel rows in the vinegar-field, to the number of several hundreds. On or beneath the field are pipes connected with the gyle-tuns; and through these pipes the gyle flows. A flexible hose is screwed to certain openings in the pipe, and by turning a valve or cock, two men are enabled to fill all the casks one after another (Fig. 111) through the bung-holes, which are placed uppermost. Here the gyle remains for many weeks, acted on by the atmosphere through the open hole; the casks are examined twice a day, and a piece of tile or slate is placed lightly over each hole when rain is about to come on. By degrees the gyle loses its former spirituous character, and becomes converted into vinegar. Then ensues the "drawing off" (Fig. 112) whereby the vinegar is transferred from the casks to larger vessels within the building. By means of a syphon the vinegar is drawn from each cask into a trough, from thence into a kind of travelling tank, and from thence through pipes into the building.

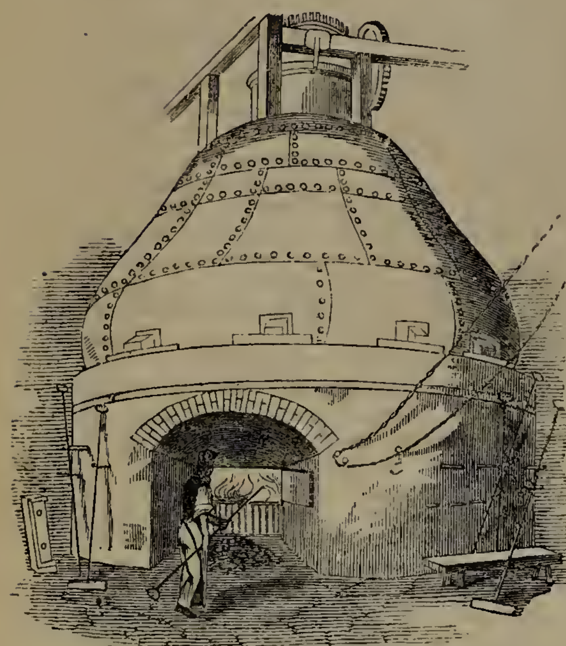
After the vinegar has been stored for some time in large vessels, it is "brightened" or "clarified" for sale, through the agency of a remarkable ingredient. This consists of the "rape" or "raffe" or stalks and skins of raisins which have been used in making raisin-wine; and as nothing else has ever yet been found which answers the purpose so well, the procuring of this rape is an important feature in vinegar-making. The vinegar is filtered through a thick bed of this material; and occasionally a thick bed of wood shavings, of straw, of tanners' spent-bark, has been employed for this purpose; but as the result is always better when rape is used, it seems to follow that mere filtration is not the only effect, but that the vinegar acquires a flavour or property from the skins and stalks. The rape is put into very large double-bottomed vessels; and the vinegar, being allowed to flow slowly into each vessel, filters through the loose mass, and passes through perforations into the space between the two bottoms; whence it is pumped up, and made to flow again through the vessel, thus keeping up a constant circulation, and allowing the vinegar to filter through the rape over and over again until it has become quite clear. The material gradually wastes away during this process, and is renewed from time to time; but so difficult is it to collect such a vast mass of raisin skins and stalks, in a country where so little wine is made as in England, that a sufficient quantity of it is reckoned one of the valuable parts of the vinegar-makers' working materials.

The making of vinegar from fruit need not engage our attention; for the must or wine of the fruit, like the wash or the gyle of corn, contains those chemical elements which by heat or air are converted into vinegar.



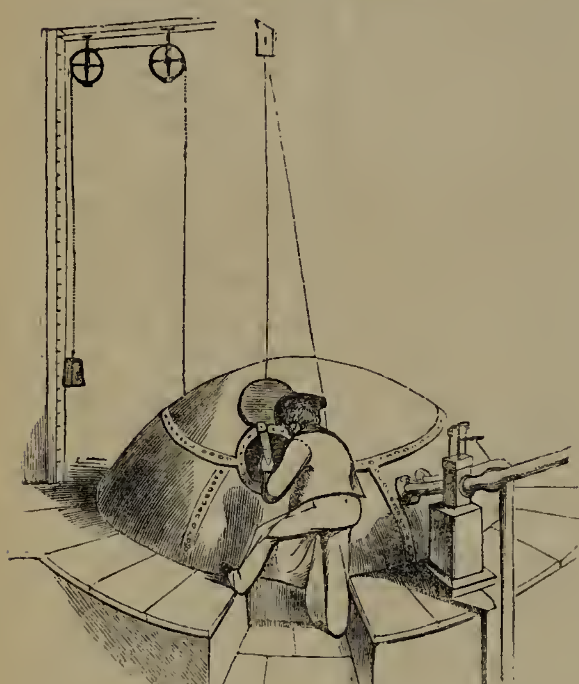
98.—Mash-tun; Distilling.

97.—Malt-distillery, Thames Bank.

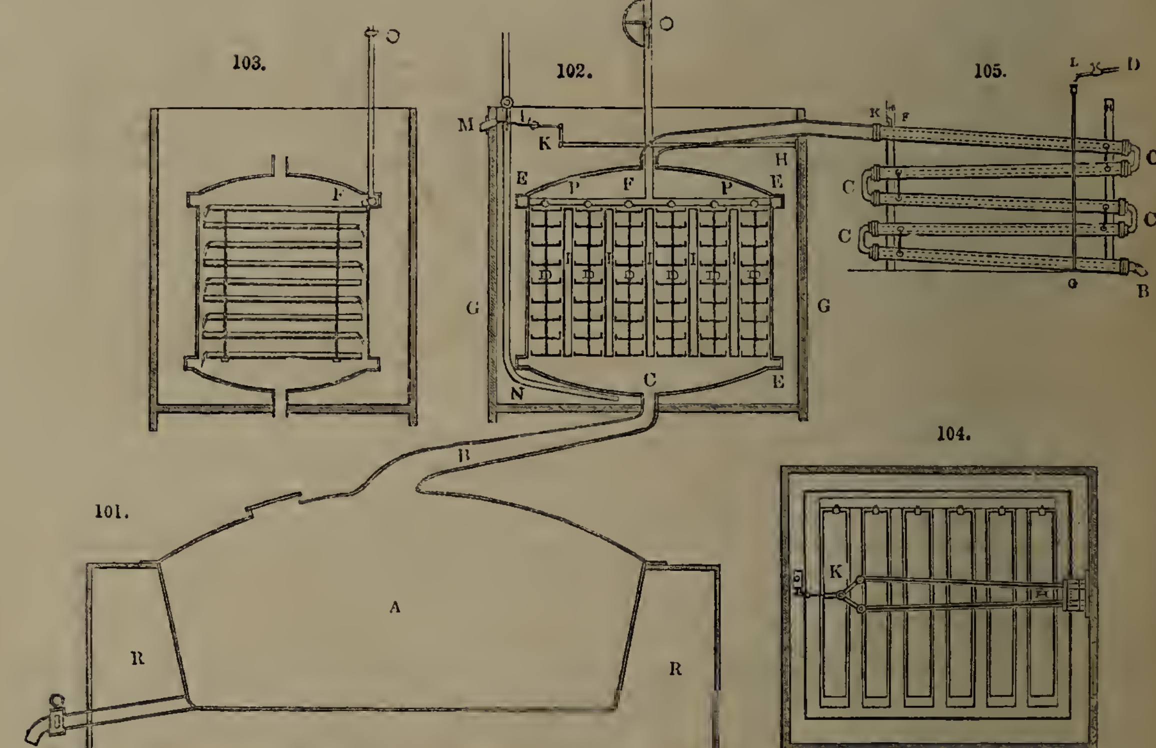


100.—Wash-still; Distilling.

99.—Cooling-floor; for cooling Beer or Spirits.



109.—Upper part of the Copper or Boiler; Vinegar-making.



101 to 105.—Distilling Apparatus.

107.—Areng saccharifera, yielding Indian Spirit.

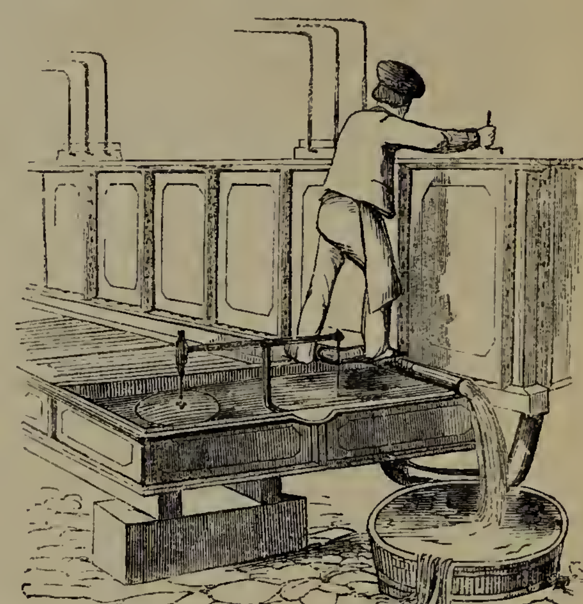
108.—Agave, yielding Mexican Spirit.

106.—Hydrometer Apparatus; Distilling.

116.—Wine manufacture: Fruit-pressing.

115.—Winemaking at Pola, in Istria.

111.—Vinegar-field: Filling the Casks.



110.—Vinegar-cooler, or Refrigerator.

112.—Vinegar field; Drawing-off.

113.—A Tyrolese Peasant at Vintage-time.

117.—Halle aux Vins, or Wine-market, Paris.

Wine-making.

So numerous and important are the applications of *corn* to the purposes of food and beverage, that when we have glanced through these applications, little else need be said in this volume concerning the employment of other vegetable produce in respect to food; since we do not profess to touch upon these matters except in so far as they involve something like art or industry in their preparation. The whole range of *fruits*, for example, are eaten much more largely in their native state, or formed into some kind of pastry, than in any way which can be said to involve manufacture. The cultivation of the ground, the planting, the pruning, the grafting, the gathering—though involving details somewhat different from those relating to corn-husbandry—scarcely come within our scope sufficiently to require consideration. The preparation of *wine* from fruits, however, must not pass wholly unnoticed.

All wine, properly so called, is made from the juice of the grape; and in those countries where the grape is best cultivated, there is the best wine made, or there at least it *may* be made, if the cultivators have the requisite skill. All the beverages produced from other fruit, such as cider from the apple, perry from the pear, and the "sweets" (as the Excise calls them) or "home-made wines" (as the purchasers call them) from the raisin, the currant, the gooseberry, the orange, &c., are rather substitutes for wine than wine itself.

The matters immediately antecedent to the making of the wine itself are rather of a picturesque and a rural than of an industrial character. Whether it be the conveying home of the produce of the vineyard (Fig. 113) on baskets or stages depending on the usages of any particular country; or in gathering the produce of orchards and fruit gardens (Fig. 114) either for the table or for the preparation of beverages, there is scarcely a country in Europe but that could exhibit its picturesque scenes, illustrating the means, the ingenuity, or the general habits and customs of the farming or provincial population. The climate of the district has, of course, a great influence on the determination of these points. Thus, in Normandy, the growth of apples is so immense as to give a decided character to the country districts. All the way from Amiens to Beauvais, a distance of more than sixty miles, is described as being one continued avenue of apple and pear trees. In no other province of France are these fruits so extensively cultivated as in Normandy; owing, as is supposed, to the unsuitable nature of its climate for the production of the grape, and the consequent necessity of supplying the absence of wine, the ordinary beverage of the French people, with cider and perry. The cultivation of apples, under these circumstances, is particularly attended to; and about the beginning of October the apple-harvest commences, when men, women, and children, sally forth with long poles to beat down the fruit, baskets to convey it to the cart, and a barrel of cider to cheer them during their somewhat arduous toils under a blazing sun. The apples are thus collected into great heaps, where they lie till the middle of November, when they are carried to the cider-press.

With relation to wine properly so called, each of the countries in the middle and south of Europe has its own proper and peculiar reputation for the kind of wine thus produced. *Port* is the produce of the banks of the Douro in Portugal, not far from Oporto. *Sherry* is derived from vineyards situated in the vicinity of Xeres in Spain. *Claret* or *Bordeaux* is the valuable produce of a small district not far distant from the city of Bordeaux. *Burgundy* and *Champagne* are the names applied to the choice wine made in these two French provinces. *Rhenish* wines, *Moselle* wines, and *Neckar* wines, are named from vineyards situated on the banks of those three rivers; and the special names, such as *Johannisberger*, *Hochheimer*, *Rüdesheimer*, &c., relate to particular vineyards which have acquired a wide-spread reputation. *Tokay* is a most expensive wine made at and named from the town of Tokay in Hungary.—Thus it is also in Italy, in Southern Germany, in Greece, and in the Mediterranean Islands: each country produces wine which, when tasted by the palate of a connoisseur, is found to possess its own peculiar properties, distinguishable from others.

The general routine of wine-making is pretty much the same in all these districts, and may be illustrated by a few examples. In sherry-making, for instance, the grapes, which are allowed to hang till perfectly ripe, are plucked before the middle of September; and those growers who are most attentive to their wines place the grapes in baskets, and expose them to the sun for forty-eight hours, turning and sorting them all the while. When the wine is to be made, the grapes are carried to the pressing-room. The presses generally used in the sherry districts are simply large wooden troughs, about eight feet square by twelve or fourteen inches deep; and each will contain, at one time, as many grapes as will yield a butt of wine. A coarse wooden screw stands in the centre of the trough, worked by a lever; and a large quantity of grapes being heaped up on one part of the trough, the labourers commence by strewing upon them a little powdered gypsum. Some of the grapes are then spread over the bottom of the remainder of the trough, upon which the men jump with great violence, having heavy wooden shoes on their feet. The grapes being then piled up round the screw, the press is worked, and the "must" or juice flows out abundantly. The bottom of each trough is elevated two or three feet above the floor of the cellar, with two or three spouts so arranged as to allow the must to fall into vessels beneath. The must is poured into butts: and the skins and husks, after having had water added to them, are again pressed, to yield an inferior quality of must. The must is allowed to ferment in casks, and gradually exchanges its sweetness for the more alcoholic quality of wine.

Of the ruder modes of expressing the juice from the grape, it is scarcely necessary to speak. The illuminations in the Harleian and other manuscripts, and the paintings on the walls of Egyptian buildings, give abundant evidence of the state of this art in the early stages of a nation's history; and the grape-pressing process adopted at Pola in Istria (Fig. 115), where a man treads the grapes in a kind of cart, and another collects the juice in vessels, will sufficiently exemplify the method still adopted in many countries.

All wine is thus fermented; but a great number of minute particulars determine the manner in which the fermented juice is brought to the state of saleable wine. Thus, in some wines, especially port, brandy is added; and in nearly all, age is an important element of goodness. Hence it arises that old wine commands a higher price than new. At Xeres there are very large cellars, in which the sherry wine is deposited, in casks which are always kept in the cellar. The casks contain wine of all ages from one year to half a century. The stock of the finest and oldest is never exhausted; according to the price at which wine expedited to the market is intended to be sold, it contains a larger or smaller proportion of old wine; but it is only in wines of a very high price that even a small portion of their very finest wines is mixed. What is withdrawn from the oldest and finest casks is made up from the casks which approach them nearest in age and quality; so that a cask of wine, said to be fifty years old, may contain a portion of the vintages of thirty or forty seasons.

The labour of the vine-dressers in the wine countries is often laborious. Thus, one of the Rhenish wines is produced at a village called Assmanshausen. The hills behind and around this village are so very steep that it is only by artificial means, often by planting the vines in baskets, that any soil can be retained around their roots. The vineyards are a succession of terraces or steps, extending from the top to the bottom of the hills, some of which are nearly a thousand feet in height. In some places more than twenty terraces may be counted, rising one above another; they are supported by walls of masonry from five to ten feet high; and the breadth of some of the ledges on which the vines grow is not more than twice the height of the walls. To reach many of these narrow plats, the vine-dressers, female as well as male, must scale the precipices and hang as it were from the face of the rocks; while a great deal of the soil itself, and every particle of manure, must be carried up on their shoulders. It has been remarked that "the life of the Rheinland vine-dresser indeed presents a rare example of industry and perseverance. Though by no means rich, they are generally the proprietors of the vineyards they cultivate; and though their appearance does not altogether verify that which painters draw or poets describe, they at least exhibit an aspect of cheerfulness and intelligence. Independently of the hardness of the labour of cultivating the vine—which is not confined to any one season, but must be carried on perseveringly through the whole year, and is most severe during the heat of summer—the vine is a delicate plant; frost, rain, or hail, may in a few hours annihilate the produce upon which the cultivator depends solely for his subsistence."

As to the manufacture of "sweets," or "home-made," or "British wines," it is a very simple affair. These wines are either made of foreign raisins, such as "muscatels," "blooms," "sultanas," "lexias," "sun-raisins," &c., or of English fruit, such as currants, gooseberries, &c.; and of some kinds of roots, such as the parsnip. Raisins are dried grapes prepared in Spain and other countries by exposing them to the heat of the sun, or to an oven, and by other means. In the autumn a supply of these fruits is laid in; and during the winter wine is made from them. The fruit is separated from the casks and boxes in which it is imported, and steeped until it has yielded all its vinous and saccharine matter; this liquor is drawn off; and the remaining skins and pulp are pressed powerfully, either by a screw-press worked by men (Fig. 116) or by an hydraulic press, until all the juice is squeezed out. A kind of fermentation then ensues by virtue of a leaven or yeast contained in the fruit itself; and by subsequent "racking," "fining," and "sweetening," the liquor assumes the state which we recognise as raisin-wine.

For the English fruit wines, and for cider and perry, the operations bear a great analogy to those here noticed; for the bruised pulp is steeped and otherwise treated until a sweet and agreeable beverage is produced from it, less alcoholic than real wine, and less narcotic than malt liquor.

With regard to the commerce and consumption of wine, it is estimated that the average consumption in this kingdom is about six million gallons per year—not more than one-fourth of the amount of spirits consumed! so much are we a spirit-drinking rather than a wine-drinking people; arising in great measure from the very large duty chargeable on foreign wine. The inhabitants of Great Britain do not consume above one quart of wine per year each on an average, while those of France drink nineteen gallons per year each, poor and rich together. It arises necessarily from this, that the arrangements for conducting the wine-trade in France are more extensive that those in England. A wine-market, properly so called, we can hardly be said to have in this country; for the wine-cellars at the London and St. Katharine's Docks are too much under the control of the Excise to come up to our ideas of an open market. In Paris, however, the matter is different. There is a "Halle aux Vins," or Wine-Market (Fig. 117), expressly devoted to this branch of commerce. It is a well-conducted establishment, and the scene of a very large trade. The piles of store-vaults are seven in number, four in front and three behind. The two centre piles fronting the river are divided into seven compartments, and are used as a market; one of the buildings in the back division is for containing brandies. The spaces between the several masses of buildings form avenues or streets, of which there are several named after different kinds of wine—as the Rue de Champagne, Rue de Bourgogne, Rue de Languedoc, Rue de la Côte d'Or. The avenue in our cut represents the Rue de la Côte d'Or. There are counting-houses for the merchants, and small bureaux for the officers who superintend the entrance and delivery of the wines. These entries amount sometimes to fifteen hundred casks a day. The whole establishment contains more than three hundred thousand square yards; it is enclosed by walls on three sides, and has a frontage towards the Seine nine hundred yards in length. The stock of wine usually stored in the Docks of London is about four or five million gallons; but that usually contained in the Parisian "Halle aux Vins" is from twelve to fifteen millions.

THE COMMERCE IN VEGETABLE FOOD.

The reader will readily understand, why we here leave the details concerning vegetable produce, and prepare to pass on to other topics. Interminable, or nearly so, as may appear the varieties, the growth, the qualities, the values of vegetable produce; yet so far as art or industry are concerned, they may be represented by the few examples which have already engaged our attention. We might extend our glance to those departments of agriculture and the cognate arts which relate to the culture of trees, of shrubs, of fruits, of flowers, of table-vegetables; we might depict the scores and hundreds of fruits which give more or less of sustenance, from the date and the bread-fruit of foreign climes to the apple and the pear of our own country (Figs. 118, 119, 120); or represent the garden-produce which reaches our dinner-tables. But other matter more closely pertaining to art must impose a limit here.

Yet we cannot altogether neglect to notice the remarkable features of commerce and industry to which the sale of this produce gives rise. Taking Paris and London as the representatives of two great countries, we may briefly watch the most observable points in that respect.

The *Marché des Innocens* (Fig. 121) is one of the largest and best of those markets through which the inhabitants of Paris are supplied with fruit and vegetables. The French make a distinction between a "*Halle*" and a "*Marché*." The former is a place of depôt for merchandise, where it is at the same time stored and exposed for sale, and is sheltered from the weather. A marché, on the other hand, is an open space of ground where articles are not stored, but merely brought for immediate sale. When the business of the day is over, the marché is a vacant space, while the halle still contains its stores. The wine-market, as we have just described, is a "halle;" while the vegetable market is a "marché."

The Marché des Innocens occupies the site of the ancient burial-ground of the church dedicated to the Innocents, which was demolished above sixty years ago. The large and remarkable fountain in the middle was executed nearly three hundred years ago, and was brought thither from a different part of Paris. It is the largest market, and is situated in the most densely populated part of all those in Paris. An eye-witness to the scene which this market presents early in the morning thus depicts it. "A visitor who sojourns at Paris for a few days only, as is the case with many of our countrymen, could take no better means of making himself acquainted with the appearance of the French peasantry, and the perfection and variety to which garden culture has attained in France, than by paying

a visit to the Marché des Innocens. Saturday should be the day selected for this purpose. The month of September is the season in which there is the greatest variety of fruit, and from three o'clock in the morning till the opening of the market at four o'clock is the most interesting time. During the day the market is occupied by the women of the halle or town-dealers, as the wholesale market is over in a few hours, and the country people have taken their departure before eight o'clock. The market then becomes encumbered with refuse vegetables, and the appearance is altogether different from that which it presents when the business of the day commences. It is computed that six thousand peasants attend the Marché des Innocens every day, many of whom come from a distance of thirty or forty miles. A London hair-dresser or a waiter at an hotel does not greatly differ in appearance from those who pursue a similar vocation in Paris; but the cultivator of the soil or the country labourer present peculiarities of manners and appearance which are not obliterated by the intercourse of capitals; and the light in which they are exhibited is more interesting to a stranger. It will soon be evident, from the class of persons who attend the Marché des Innocens, that the tenure of landed property in France is very different from that which prevails in England. Instead of the team of fine cattle attended by the servants of the market-gardener, who rents the well-cultivated grounds in the neighbourhood of the capital, for which he can afford to pay the landowner an enormous rent; the produce is brought to the Paris market by the landowner himself, who, with his family, and perhaps a labourer, cultivate a few acres of some large estate which was divided at the Revolution, and sold as national property."

The small proprietor, then, is his own market-dealer, and he thus proceeds. The man, with perhaps his wife and son or daughter, set out with their produce in a covered cart on the previous afternoon, and travel during the night. From midnight until the hour when the markets opens, the arrivals are incessant. Many women ride to the market on horseback, with their produce contained in large panniers. The vehicles and the animals are less neat and valuable than those of the English market-gardener, but more so than those of the London "coster-monger" who attends Covent Garden. About an hour before the commencement of business, the scene is described as being very peculiar and striking, and presents something like the appearance of a bivouac; the men, wrapped in their coarse cloaks by the side of their hampers and panniers, endeavouring to snatch a few moments of sleep before business commences, or conversing in groups. When the market-bell rings at four o'clock, a scene of much animation ensues; the white and singular caps of the women, and the volubility of so many hundred tongues, giving to the eye and ear much to rest on. All the retail dealers in fruit and vegetables attend; many private families, also, whose consumption is large, send an experienced servant to make purchases at this hour, as the open market is far more economical than the shop, and the choice much greater.

The inhabitants of Paris are more cheaply supplied with fruit and vegetables than those of London. This appears to arise from several causes: the Parisians live less substantially, but upon a greater variety of articles, than those of London; and from the mode in which landed property is divided in France, the cultivation of fruit and vegetables is more fitted for the small farmers or cultivators of France than for the large farmers of England. Yet, whoever has been at Covent Garden Market betimes in the morning will have seen that the large arrangements and the universal bustle indicate an extensive sale of garden produce.

There is perhaps hardly any one in England ignorant of the celebrity of Covent Garden as a market, though it is perhaps only among readers that the fact is known of this site having been once the *Convent Garden* of the Abbots of Westminster. On the dissolution of the monasteries it was given to the Duke of Somerset, and afterwards to the Earl of Bedford. For a time it was used as a pasture-ground, then it was let on building-lease, then Inigo Jones was employed to plan and execute the piazza which partly encompasses the open area; and by degrees the open area itself, without any regular intention seeming to have led to such occupation, became occupied by dealers in market-produce. Rude and unsightly buildings were erected from time to time to accommodate the buyers and sellers; but it was not till about fifteen years ago that the present commodious and rather elegant market was constructed (Fig. 122). Garden vegetables, fruit, and flowers, are all sold in large quantity; as likewise are numerous varieties of seeds, herbs, and medical drugs. The casual traders pay a toll proportionate to the quantity and value of the produce which they bring to the market; but those who occupy shops or stands by the week or by the year, and who sell by far the greater part of the produce brought in, merely pay their rents as they would do in occupying a shop anywhere else.

Here, as at the Marché des Innocens, a scene of great animation is presented to those who have courage to leave their beds early enough to visit it at the proper hour. Covent Garden market is open daily; but there are three mornings in the week which are deemed "market mornings." On these mornings, at about four o'clock, the sale of garden produce is going on very rapidly. There are "higglers" who act as a sort of middle men, and who buy at once from the growers, with a view to sell at a profit almost immediately afterwards to the smaller dealers. These smaller dealers arrive from about five to eight o'clock, and then begins the busiest time: the greengrocers come in their carts; porters rush about with tiers of baskets on their heads; and clamouring is heard on every side. Near the pillars of the piazzas, too, are breakfast-stalls in plenty, where the slices of bread and butter, and the basins of coffee, derive an additional relish from the good appetite which the morning exercise has given to the partakers.

Fulham is the centre of the district which most largely supplies Covent Garden market with vegetables. Even so long ago as the Norman Conquest, the vicinity of Fulham and Hammersmith supplied a great portion of the vegetable food eaten by the Londoners; but it was not until the time of Charles the Second that the regular system of supply became established. Apples, pears, cherries, plums, walnuts, raspberries, gooseberries, and currants, among the fruits; lettuce, cabbages, onions, salad, peas, beans, radishes, parsley, spinach, potatoes, turnips, cauliflowers, broccoli, carrots, parsnips, among table-vegetables—all are cultivated more or less in the Fulham district, for Covent Garden Market. As several of these kinds of vegetables ought to be eaten as soon as possible after being gathered, the gardener gathers one day and sells the next; and hence the intervening night is the period of conveyance. The roads are crowded with market-carts, on the nights preceding the three market-days, all destined to reach the busy market by three or four o'clock. Every gardener has his market-cart, which he loads at sunset, and dispatches it off at an hour depending on his distance from London; a driver and a seller accompany the cart, and return with it next morning. During the strawberry season, the fruit is carried in baskets on the heads of Welch or Shropshire women, who show a wonderful power of endurance at this work; they carry forty or fifty pounds' weight from Hammersmith or Fulham to the market, and then return for a second and similar load!

There is something very remarkable in the social and commercial machinery (if we may use such a term) whereby a large city is uninterruptedly supplied with its daily quota of food. We are so accustomed to *command* a supply of these things, if we have the means of paying for them, that a deficiency of the supply never seems to enter the thoughts. Yet the means for effecting this are very striking. The Archbishop of Dublin (Dr. Whately) in his 'Introductory Lectures on Political Economy' has presented the matter in the following vivid light:—"Let any one propose to himself the problem of supplying with daily provisions of all kinds such a city as our metropolis, containing above a million of inhabitants. Any considerable failure in the supply, even for a single day, might produce the most frightful distress; since the spot on which they are contained produces absolutely nothing. Some, indeed, of the articles consumed admit of being reserved in public or private stores for a considerable time; but many, including most articles of animal food, and many of vegetable, are of the most perishable nature. As a deficient supply of these, even for a few days, would occasion great inconvenience, so a redundancy of them would produce a corresponding waste. Moreover, it is essential that the supplies should be distributed among the different quarters, so as to be brought almost to the doors of the inhabitants, at least within such a distance that they may, without an inconvenient waste of time and labour, procure their daily shares. Moreover, whereas the supply of provisions for an army or garrison is comparatively uniform, here the greatest possible *variety* is required, suitable to the wants of various classes of consumers. Again, this immense population is extremely fluctuating in numbers; and the increase and diminution depend on causes of which some may, though others cannot, be foreseen. Lastly, and above all, the daily supplies of each article must be so nicely adjusted to the stock from which it is drawn—to the scanty or more or less abundant harvest—to importation or other source of supply—to the interval which is to elapse before a fresh stock can be furnished—and to the probable abundance of the new supply, that as little distress as possible may be undergone; that, on the one hand, the population will not unnecessarily be put upon short allowance of any article; and that on the other hand they may be preserved from the more dreadful risk of famine, which would ensue from their continuing a free consumption when the store was insufficient to hold out."

Yet, vast as are the complications and niceties here sketched, there is a sort of self-regulating power, a mutual spirit of interchange, which adapts the demand to the supply with more precision than any law or body of laws could ensure.

DAIRY INDUSTRY.

THERE are a few points, and only a few, which may call for our attention in reference to the application of art or industry to the rearing of domestic animals.

In what manner the ox, the calf, the sheep, and the pig, are brought to the condition most favourable for the butcher; how the cow is fattened and tended to yield the largest quantity of milk; how domestic poultry and the minor denizens of the farm-yard are reared—are matters foreign to our present object; but the application of milk to the making of cheese and butter, and the curious application of art to the hatching of fowls' eggs, require a passing glance.

Cheese and Butter-Making.

The mechanical aid to the making of cheese is very simple; the difference of quality lying rather in the mode of procedure than in the kind of implements employed. Some cheeses, such as "cream," "Bath," and "Yorkshire" cheeses, are soft and rich: they are not intended to be kept long, and are in fact sold as soon as made, for fear of becoming putrid. Another class consists of the hard and dry cheeses, such as the "Cheshire," "Gloucester," and "Dutch" cheeses. "Stilton" cheese is intermediate between these two classes. The general character of cheese may, however, be thus considered. Milk consists of three portions or distinct principles, which are easily separable one from another by heat, air, and other agencies: one is the cream, which, when separated from the other, yields *butter;* the second, a solid curd of a very different nature, is the basis of *cheese;* while the liquid residue constitutes *whey*.

In making cheese, the first thing is to separate the curd from the whey, a process which depends on the kind of cheese to be made; it may be done by allowing the milk to become sour; or by adding muriatic or other acids; or by introducing the flowers or the juice of certain vegetables; but the best and most general agent for effecting this is by adding to the milk a portion of *rennet*, the prepared stomach of a sucking-calf. Nature has given to the calf a certain power of decomposing milk when introduced into the stomach: and this stomach, when taken from the animal immediately after being killed, and prepared in a particular manner, is fitted to curdle milk in the manner required for cheese. A piece of this rennet is soaked in whey or water when required for use, and imparts to the solution the requisite coagulating or curdling quality.

The milk to be coagulated is made warm; the rennet liquor is added to it; the two are mixed and worked about till the curd is formed; and this curd goes through a number of subsequent processes, generally including colouring, shaping, and pressing, until it arrives at one or other of the many well-known forms of cheese. Every country, every province, nay, in many provinces, every village has its own peculiar mode of managing some or other of the processes; so that, in point of fact, the varieties of cheese are in principle almost infinite. There are, however, about a dozen distinct varieties largely known in this country, sufficiently different one from another to form classes or groups. Warm milk, curdled by some means or other, and this curd worked up to a firm state, is the general character of all cheese, with a few exceptions; and it will be readily understood how and in what matter diversities may arise.

Butter, in like manner, is subject to diversities; but here again there is a general resemblance in the modes of making all. Of the three constituents of milk—cream, curd, and whey—cream is the lightest, and collects gradually at the top; whereby its separation is brought about readily. The mode of procedure involves the following points (omitting minor diversities). Milk is drawn from the cow into vessels of wood, tin, or copper, scrupulously clean; and is immediately strained through a fine sieve or cloth into shallow pans or troughs made of lead, of tinned iron, or of brass. The milk in the trough is four or five inches in depth; and the trough is then set aside in a place which is open to the free access of air, but shielded from sunshine, and from every kind of smoke or odour, since the milk in this state is one of the most susceptible of substances, influenced greatly by all the circumstances with which it is associated. When the milk has stood twelve hours, the finest parts of the cream have risen to the surface; but by another detention of twelve hours, the quantity thus accumulated is greater, and it is then skimmed off, or else the milk is allowed to flow away from beneath it. When a sufficiency of the cream is collected in a deep earthen jar, preparations are made for *churning*, by which the cream is converted into butter. The churn is a wooden cask, rather wider at bottom than at top, covered with a round lid having a hole in the centre; through this hole passes a round stick about four feet long inserted in the centre of a round flat board with holes in it; the diameter of this board being a little less than that of the top of the churn. Other forms of churns have been devised. Thus, in the Derbyshire churn (Fig. 123), *a* is the churn, *b* the beaters, *c* the handle, and *d* the cover. In the Lancashire

121.—Marché des Innocens, Paris.

122.—Covent-Garden Market.

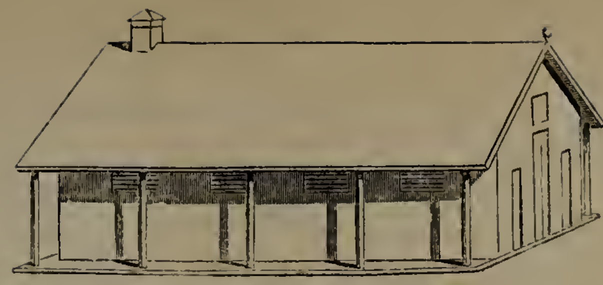
120.—a, Apple; b, Pear; c, Quince; d, Medlar.

118.—Date.

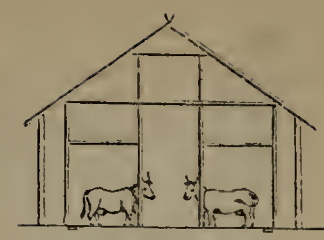
119—Bread-fruit.

114.—Apple-gathering in Normandy.

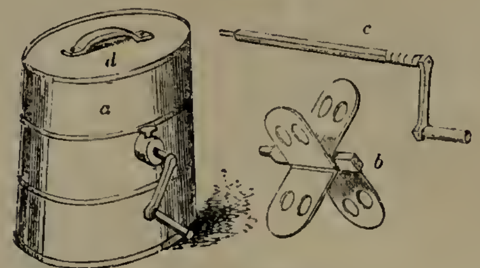
133.—Egg-marketing in Ireland.



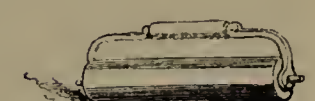
126.—Side view of a Dutch Cowhouse.



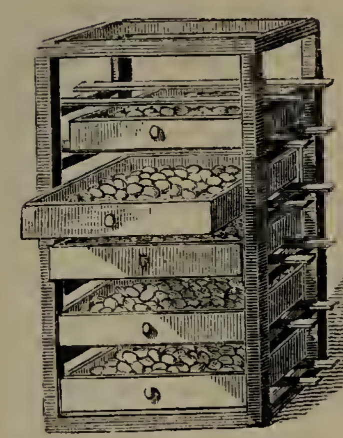
127.—Section of 126.



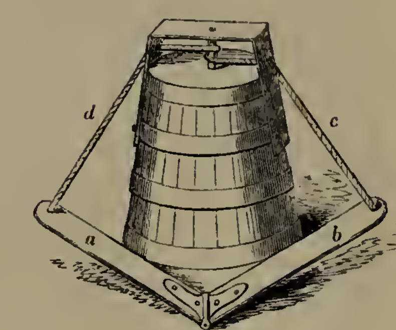
123.—Derbyshire Butter-churn.



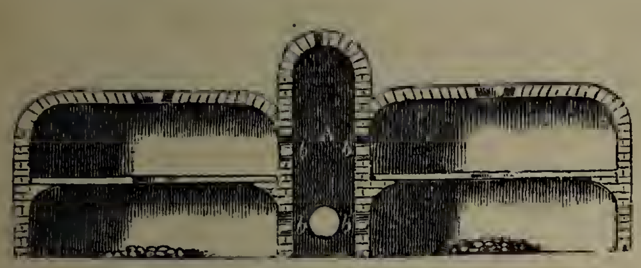
125.—Butter-roller.



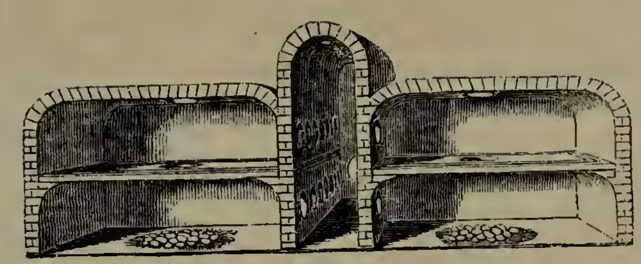
130.—Egg-frame.



124.—Lancashire Plunge-churn.



128.—Transverse Section of Egg-oven.



129.—Perspective Elevation of Egg-oven.

131.—Hatching-room, over the Bakehouse Ovens of the Priory of L'Enfant Jesus, at Paris.

134.—Market for Butter, Eggs, and Cheese, at Paris.

132.—Artificial Mother.

churn (Fig. 124) a person treads alternately on the two boards *a b*, which causes the strings *c d* to work the beaters. The cream being put in the churn, to about two-thirds of its height, it is violently agitated, by means of the stick held in both hands and moved up and down, the cream passing through the holes in the board and round its edge every time the stick is raised or depressed, and thus every portion is brought into contact with the air. By degrees small kernels of butter appear, and these soon become united into a mass of solid butter. The butter is collected with the hands, and placed in a shallow tub, and beaten sometimes with an artificial hand or roller (Fig. 125), and washed until the remaining liquid, or "butter-milk," is driven out from it. The butter is then brought to a finished state; and is made into *rolls* of fresh butter, weighing two pounds each, or into *prints*, weighing a pound or half a pound each, or is brought to the state of *salt* butter by adding from three to five pounds of salt to half a cwt. of butter, and then placing it in firkins or casks.

The Dutch are particularly clean and careful in all that relates to cows, milk, cheese, and butter. Figs. 126, 127, give an idea of the manner in which their cowhouses are arranged. There is a verandah running round three sides of it; and the interior has a broad central passage, from end to end. The cows stand with their heads towards this passage, and their tails towards the wall; sometimes their tails are kept up by a cord tied to their ends, and passed over a pulley with a weight at the other end. There are spaces in the cowhouse used as depositories for the green food or roots destined for the day's consumption; while another is the hay-loft. The food is brought in carts, which are driven at once between the cows; that portion which is not wanted immediately is stored above, whence it is readily thrown down before the cows; thus much trouble is saved, and one man can feed and attend to a great many cows. From November till May the cows never leave the cowhouse. In summer, when they are out, if they are in adjacent pastures, they are driven home to be milked; but if the pastures are far off, which is sometimes the case, they are milked there, and the milk is brought home in boats.

Artificial Incubation, or Egg-Hatching.

From the dairy and its industrial processes we pass to those connected with the rearing of poultry, solely with a view of noticing the curious mechanical arrangements which have been proposed for effecting the incubation or hatching of eggs, without the "sitting" of the hen—nature's own process.

The inhabitants of the village of Berme in Egypt have such skill in this practice of artificial hatching, that they are employed by country people elsewhere, and keep the secrets of their trade carefully to themselves. When the beginning of autumn (the season most favourable for hatching) approaches, they visit their country customers in different parts of Egypt, and each one takes the management of a number of eggs intrusted to his care by those unacquainted with the art.

The *mamal*, or Egyptian hatching-oven, employed by these people, is a brick structure about nine feet high. Figs. 128 and 129 will give some idea of the transverse elevation and the perspective elevation of the oven. The middle is formed into a gallery about three feet wide by eight high, extending from one end of the building to the other. This gallery forms the entrance to the oven, and commands its whole extent, facilitating the various operations indispensable for keeping the eggs at the proper degree of warmth. On each side of this gallery there is a double row of chambers, every chamber on the ground-floor having one over it of precisely the same dimensions, about twelve feet by four, and three in height. These have a round hole for an entrance, about eighteen inches in diameter, wide enough for a man to creep through. The number of chambers sometimes amounts to twelve in each mamal; and as there are four or five thousand eggs placed in each room, there are thus fifty or sixty thousand in the oven. In each of the upper chambers is a fire-place for warming the lower one, the heat being communicated through a large hole in the centre. The fire-place is a sort of gutter, two inches deep by six wide, on two or on all four sides of the upper chamber. As wood or charcoal would make too quick a fire, dried cow or camel's dung, mixed with straw, is used for fuel. The doors which open into the gallery serve for chimneys to let out the smoke, which finally escapes through openings in the arch of the gallery itself. The fires are kept in for an hour at a time, two or three times a day, according to the weather. When the smoke of the fires has subsided, the openings into the gallery for the several chambers are carefully stuffed with bundles of coarse tow, by which the heat is more effectually confined than by a wooden door. When the fires have been continued for an indefinite number of days—eight, ten, or twelve, according to the weather—they are discontinued, the heat acquired by the ovens being then sufficient to finish the hatching, which requires in all twenty-one days, the same as when the eggs are naturally hatched by a hen. About the middle of this period, a number of the eggs in the lower chambers are moved into the upper, in order to give the chicks greater facility in making their exit from the shell than they would have if a number of eggs were piled up above them.

It is supposed that there are about four hundred of these egg-ovens in Egypt, all managed by inhabitants of Berme, whose success seems to depend on the careful management of the temperature. The number of eggs exposed thus to this artificial process is probably about a hundred millions in a season; but the men never undertake to return more than two-thirds the number of chicks, an allowance of one-third being made for the various sources of failure. If the men hatch more than two-thirds they keep the surplus, in addition to the wages of thirty or forty crowns per man, together with board, for the season.

Réaumur, the celebrated French naturalist, paid a good deal of attention to this curious process; and the next three cuts (Figs. 130, 131, 132) show some of the arrangements adopted by him. He first tried the plan of immersing the eggs in dung beds; but he found that the heat generated by the fermentation became so great as almost to cook the eggs. As a next plan he employed a hot-bed only to heat a cavity or oven, instead of plunging the eggs into it; he formed two such beds, not so wide as cucumber-beds, parted by a narrow path closed at the end, thereby forming an oblong cavity, into which the eggs were placed, and in which the air was warmed by the fermentation of the beds. Two or three attempts of this kind failed; and Réaumur thereupon had ovens of various kinds built; but so many are the points requiring care in this delicate operation, that the ovens did not effect the desired object. After repeated trials, he conceived the idea of placing the eggs in shallow baskets, putting these baskets into hogsheads or casks, and imbedding the casks in hot-beds. This so far succeeded, that several of the chicks were hatched in due time. He next wished to try whether the heat of a common baker's oven might be made applicable, besides rendering its wonted service, to the hatching of eggs. He selected the bread ovens belonging to the extensive benevolent institution called L'Enfant Jésus. After several trials to ascertain the heat of a room which was situated over this bakehouse, he determined to arrange the eggs on the shelves of a small cupboard placed there, and to entrust the care of them to the nuns of the establishment. The attempt was to a considerable degree successful. Réaumur also employed a stove having an apartment round it to contain the young chicks, and a net-work to prevent their escape.

The problem seems to consist in maintaining a particular temperature for a particular time, with the absence of any deleterious matter which might penetrate the shell and kill the chick. Some years ago the process of "hatching by steam" attracted some note in London; but, as a commercial speculation at least, it appears to have died away. "Artificial mothers" for aiding in many ways the process of hatching have been devised in this country as well as abroad.

The Commerce in Dairy-produce.

A word or two respecting the commerce in these articles. In country districts there are no articles of farm and dairy produce more readily brought to market in a humble way than eggs and poultry. Each district has its own picturesque scenes to present, arising from the market-journeys of those who have such produce for sale. In Ireland, for example, many such primitive market-dealers may be seen as we have sketched in Fig. 133. The little rough pony has two *kishes* or panniers slung, one on each side; each pannier being a sort of upright basket, swung over on a pad of twisted straw by ropes of the same material. This sort of pannier is used all over the south and west of Ireland for the carriage of eggs, potatoes, turf, &c. The daughters of the humbler class of gardeners and farmers frequently take upon themselves this mode of going to market; and in many parts of the county Cork women may be frequently met with thirty miles distant from their homes, with baskets of this kind swung across their backs, collecting eggs from the cottages, for the sake of carrying them to Cork for sale.

In large towns, however, the supplies of these commodities is less precarious. In Paris, for instance, there is a "Marché à la Volaille" (Poultry Market), and a market for butter, eggs, and cheese (Fig. 134). Thirty years ago it was estimated that, of the usual kinds of poultry, Paris consumed the following quantities:—About a million pigeons, a million and a quarter of fowls, half a million of turkeys, and three quarters of a million of geese, capons, and ducks, taken together. These are very much larger numbers than are consumed in London; arising from the difference in price, from the difference in taste or liking, and from the much greater scarcity of game, such as hares, rabbits, partridges, &c., in France than in England. About half a million of money is spent in Paris for butter annually; but the quantity so purchased is disposed of in a very different way from that used in England. Englishmen of almost all ranks are accustomed to take an afternoon meal, which, under the denomination of "tea," involves the eating of butter with some one of the many kinds of bread; but a Frenchman understands very little about this afternoon meal, nor does he deem butter an indispensable accompaniment to the breakfast-table. In short, the French are not a *bread and butter* people, and nearly all the butter used by them is employed in the multifarious cookeries for which they are so famous.

The butter is brought to market, not in barrels, but in cloths. The market opens every day at noon; butter and eggs being sold on Monday and Friday; cheese on Tuesday; and two particular kinds of butter on the other three days of the week.

As to the mode of dealing in these commodities in London, it is pretty well known. There are markets chiefly devoted to them; and in respect to such as come from abroad, there are wholesale warehouses to intervene between the importer and the consumer. It is very doubtful whether accurate means exist for stating the quantity of these kinds of produce consumed in London or in England; but it is known that, besides those reared in this country, there are from fifty to a hundred millions of eggs imported from France yearly; and if we could trace all the commercial arrangements connected with cheese, butter, eggs, and poultry, we should probably find that they assume a magnitude and importance by no means trifling.

ART AND INDUSTRY AS APPLIED TO FISHING.

The varieties in the form, habits, qualities, and uses of fish, are matter for the naturalist; but there are a few curious and interesting points relating to fishing involving details which may fittingly close the first chapter of our volume.

Salmon-fishing—Its Varieties.

Fishing, like all other industrial arts, requires the use of implements and mechanical arrangements. These may be exemplified by taking as instances the modes of capturing a few of the most usually known fish. Let us begin with the *Salmon* (Fig. 135). The salmon is both a salt-water and a fresh-water fish, residing in the one or the other according to the season of the year. Hence the salmon-fishing may be carried on high up a river, or where it empties itself into the sea, or at some intermediate point; and the mode of fishing depends very much on the determination of this locality. One of these modes is by the *stage-net* (Fig. 136). This apparatus is stretched out between high and low water mark; the "leader," which terminates at high-water mark, is formed of stakes, between which branches of trees are interwoven like wicker-work. The part where the stage and nets are fixed touches at the extremity of the line of low water. The fishermen are stationed on the top of the stage or platform, and see or feel when a fish enters one of the bag-nets, which is immediately drawn up to the top of the stage, and the fish taken out and killed.

The "stake-net" (Fig. 137) is much more efficacious, and is largely employed on the Solway. The two lines of stakes at each end, hung with netting, obstruct the progress of the fish in their passage up the river, and are termed "leaders," being intended to conduct the fish into the inner court or chamber, within which, at one end, there are smaller divisions or chambers, in which they are taken. The court opposed to the flow of the tide only takes fish when it is a flood tide; but as salmon often move backwards and forwards in a tide-way, some stake-nets are placed in a direction to catch them when the tide ebbs.

Many other varieties of net or snare are used, such as the *coble-net*, the *cruive*, the *halve-net*, the *cairn-net*, &c. The coble-net is a peculiar kind of net attached to a flat-bottomed boat. A *cruive* is an artificial space or dyke in the river, formed of stones, projected in such a manner that the fish, in pushing up the river, are led into them, and are there enclosed as in a trap; the cruive is less efficient than the net, though not requiring such constant attention on the part of the fisher. The *halve*-net is a net fixed at the end of a pole fourteen or sixteen feet in length; the mouth of the net being stretched out. The fisherman carries the net upon his shoulder down to the river or frith, and putting it in the water, awaits the entrance of the fish. The *cairn*-net is used when the rivers are flooded. A quantity of stones are placed in the river, near the bank, when there is a flood; and in the eddy or pool a net of a peculiar description is placed. The fish seeking the side of the river at such times, the cairn-net is set there to catch them. But this mode of fishing is deemed a kind of poaching, and is not countenanced by the laws of the fisheries.

There is also a kind called "still-fishing;" in which one end of the net is held by a man on the shore, while the fisherman goes out in a boat with the other end in his hand. When a fish is seen approaching, it is surrounded with the net, and pulled ashore. At Thurso this method is practised by means of a very long net, which is stretched out about half its length, in a direct line, into the sea; two men are placed in a boat, one at each end, looking in opposite directions, until they

see a fish leap or swim, when they shoot the net in the direction which it is supposed to have taken, and on the fish being enclosed, it is dragged ashore. Another method yet of netting salmon is that which is called "setting." In the upper portion of a salmon-river in the long pools of deep clear water, a large number of nets are placed in every direction; and the water being disturbed by boats or lights, the salmon are driven into the nets and caught.

But by far the most exciting and attractive mode of salmon-fishing is that in which the *spear* is used instead of the net. The simplest mode of conducting this is the "spearing," as carried on in some of the rivers of Devonshire. About the middle of September the spearers or fishers clear out the resting-places of the salmon, and, taking away the largest stones, put in about a dozen stones perfectly white, which they arrange in a circle. The spearmen return to the place about ten or eleven o'clock at night, and if the stones are not discernible, they are sure a fish is there, and strike at them with a ten-pronged spear. This is deemed an illegal mode of fishing; and the Scotch adopt another variety of it called "stream-fishing" (Fig. 138). A dyke of loose stones is constructed in the river, which acts a "leader" to the fish coming up the stream, directing them to the channel next the bank; at the end of the dyke there is a hut constructed of branches of trees, in which the fisherman awaits the approach of the salmon, which he strikes with a five-pronged instrument.

The spearing by torch-light is, however, the most striking mode of conducting this variety of salmon-fishing. Where there are only two or three persons engaged, the nets are spread beneath and around a boat in which two persons stand armed with spears. A third individual holds a light made generally of tarred rags; and when, by a gleam from this light, a fish is observed within reach, it is immediately struck and killed. But where there are several parties engaged as in Fig. 139, the scene becomes extremely animated. This method is pursued near the mouths of the Scotch rivers, or in the lochs, and it is of some such scene that Sir Walter Scott speaks in 'Guy Mannering.' He says:—"The chase in which the fish is pursued and struck with barbed spears, or a sort of long-shafted trident called a 'waster,' is much practised at the mouth of the Esk, and in the other salmon-rivers of Scotland. The sport is followed by day and night, but most commonly in the latter, when the fish are discovered by means of torches or fire-grates, filled with blazing fragments of tar-barrels, which shed a strong though partial light upon the water. Upon the present occasion, the principal party were embarked in a crazy boat upon a part of the river which was enlarged and deepened by the restraint of a mill-wear; while others, like the ancient Bacchanals in their gambols, ran along the banks, brandishing their torches and spears, and pursuing the salmon; some of which endeavoured to escape up the stream; while others, shrouding themselves under the roots of trees, fragments of stones, and large rocks, attempted to conceal themselves from the researches of the fishermen. These the party in the boat detected by the slightest indications; the twinkling of a fin, the rising of a air-well, was sufficient to point out to these adroit sportsmen in what direction to use their weapons." Of the fish obtained by these means, "the best were selected for the use of the principal farmers; the others divided among their shepherds, cottars, dependants, and others of inferior rank who attended. These fish, dried in the turf-smoke of their cabins or shealings, formed a savoury addition to the mess of potatoes, mixed with onions, which formed the principal part of their winter food."

Besides the *net* and the *spear*, salmon are largely caught by the *rod*. This last method, of angling, is a means of providing for private consumption, and may be regarded more as a matter of amusement and recreation than as an employment. This mode of salmon-fishing is extensively pursued on the banks of the most productive salmon-rivers, such as the Tweed.

Mackerel-Fishing.

There are interesting details connected with the practical modes of catching most of the usual English fish, and indeed of fish in other countries; but a few rapid glances at some of them will suffice here.

The *mackerel* is a fish which frequents nearly every part of our coasts; but is most abundant off the coasts of Sussex, Kent, Hampshire, Suffolk, and Norfolk. As the flesh of the fish is very tender, great dispatch is used in conveying it to market immediately after it is caught; and this gives much animation to the whole of the arrangements connected with the mackerel-fishery. The mackerel approaches the coast in large shoals, and these shoals are generally attacked by the fishermen during the night. There are three modes of fishing for mackerel; by the *line*, by the *sean*, and by the *drift-net*. The French go out in boats, and fish by the line method; two men being able to take from five hundred to a thousand fish in a day, if the weather be favourable; the mackerel being a fish which bites at the bait voraciously. The *sean-fishing* requires two boats, and the use of a particular kind of net which we shall presently speak of in connexion with the pilchard-fishery.

The *drift-net* method is that usually practised off the English coasts, and is thus described by Mr. Yarrell:—"The drift-net is twenty feet deep by a hundred and twenty feet long, well corked at the top, but without lead at the bottom. They are made of small fine twine, which is tanned of a reddish-brown colour, to preserve it from the action of the sea-water, and it is thereby rendered much more durable. The size of the mesh about two inches and a half, or rather larger. Twelve, fifteen, and sometimes eighteen of these nets are attached lengthwise, by tying a long thick rope, called the 'drift-rope,' and, at the ends of each net, to each other. When arranged for depositing in the sea, a large buoy attached to the end of the drift-rope is thrown overboard; the vessel is put before the wind; and, as she sails along, the rope with the nets thus attached is passed over the stern into the water till the whole of the nets are run out. The net thus deposited, hangs suspended in the water perpendicularly twenty feet deep from the drift-rope, and extending from three-quarters of a mile to a mile, or even a mile and a half, depending on the number of nets belonging to the party or company engaged in fishing together. When the whole of the nets are thus handed out, the drift-rope is shifted from the stern to the bow of the vessel, and she rides by it as if at anchor. The benefit gained by the boats hanging at the end of the drift-rope is, that the net is kept strained in a straight line, which without this pull upon it would not be the case. The nets are shot in the evening, and sometimes hauled once during the night; at others allowed to remain in the water all night. The fish, roving in the dark through the water, hang in the meshes of the net, which are large enough to admit them beyond the gill-covers and pectoral fins, but not large enough to allow the thickest part of the body to pass through. In the morning early, preparations are made for hauling the nets. A capstan on the deck is manned, about which two turns of the drift-rope are taken. One man stands forward to untie the upper edge of each net from the drift-rope, which is called 'casting off the lashings;' others hand in the net with the fish caught, to which one side of the vessel is devoted; the other side is occupied by the drift-rope, which is wound in by the men at the capstan."

Some of the mackerel-boats, when they have secured their cargo, proceed at once to Billingsgate, their best market; some are attended by fast-sailing cutters, belonging to the London salesmen, which bring the fish up the Thames; sometimes vans are employed to bring the fish from Hastings and other ports; sometimes a steam-tug is employed to draw the vessels quickly up the river; and in our own day the railways seem likely to facilitate greatly the quick conveyance of the fish up to London—an object of the highest importance to the interests of all concerned; for as it has been observed, "10,000 mackerel worth 200*l.* in the morning, would not be worth 20*s.* on the following day." The price at Billingsgate depends most remarkably on the priority of arrival; a boat reaching there at seven o'clock in the morning, though containing fish equal in quality to that brought by another boat two hours earlier, would sell for a very much lower price than the latter. An instance has been recorded, in which the first boat secured forty guineas for the same quantity of fish which brought only thirteen in the second boat. At the sea-coasts the sale is often managed in a very primitive manner, by a sort of Dutch auction (Fig. 140). The plan is to separate the fish into heaps as soon as they are landed; and the persons desirous of purchasing being assembled, one of the fishermen or owners of the boat acts as salesman, and names a price *above* the real value, at the same time elevating a stone with which to "knock down" the lot. The salesman names a lower and a lower price, until at length he names a price at which one or other of his customers is inclined to purchase; the stone falls, and the bargain is concluded.

Pilchard and Herring Fishing.

The ***Pilchard*** is a fish found chiefly on the coasts of Devon and Cornwall, and is caught by the *drift-net* or by the *sean*. The former we have just described, and the latter may here be slightly noticed. A sean-fishery requires three boats and about eighteen men to work together. There are two nets employed; one of which is the "stop-sean" a quarter of a mile in length and a hundred feet in depth; the other is the "tuck-sean," half as long as the other, but somewhat deeper, and having a hollow in the middle. One boat carries the stop-sean, another the tuck-sean, and the third conveys the men to and from shore. The men go out toward evening, and anchor in some fine sandy bay, where they expect a shoal will pass; and when they have ascertained the position and extent of the shoal, the stop-sean (which has corks at the top and leads at the bottom to keep it in position) is cast into the sea. "The sean," says Mr. Yarrell, "at first forms a curved line across the centre of the fish; and while the two larger boats are employed in warping the ends together, the third one's station is in the openings, where by dashing the water the fish are kept away from the only place of escape. When the sean is closed and the ends are laid together, if the body of the fish be great, and the sea or tide strong, the net is secured by heavy grapnels, which are attached to the head-ropes by hawsers. When the evening has closed in, and the tide is low, they proceed to take up the fish. For this purpose, leaving the top-sean as before, the second vessel passes within it, and lays the tuck-sean round it on the inner side; it is then drawn together, so as gradually to contract the limits of the fish, and raise them from the bottom. When disturbed they become exceedingly agitated; and so great is the force derived from their numbers and fear, that the utmost caution is used lest the net should either sink or be burst. When the tuck-sean is thus gradually contracting, and the boats surround it, stones suspended from ropes called 'minnies,' are repeatedly plunged into the water at that part where escape alone is practicable, until the fish then to be taken are supported in the hollow or bunt of the sean." Instances have been known in which five million pilchards have been caught at once! But when the number taken is very large, only so many are taken out of the net at one time as the boats can conveniently carry, and a week or ten days may elapse before the whole are secured.

The *herring* is one of the most important of British fish, in relation to the extent of the traffic to which it gives rise. These fish form a winter rendezvous within the Arctic circle; and in the spring months they travel southwards in shoals, sometimes six miles in length by three or four in breadth. When a great shoal approaches the northern extremity of Britain, it divides into two; one part travelling down the western shore and the other the eastern. This account of the vast migration in a mass, first given by Pennant, has been supported by most writers and discountenanced by some; but the point need not be discussed here. Suffice it to say, that at Yarmouth, the chief herring station, the fishery commences about the middle of September. The vessels employed are of two sizes; if they are intended for the capture of those to be afterwards cured into "red herrings," the boats are small, keep within a moderate distance of the shore, and bring the fish on shore to be cured; but if "salt" or "white herrings" are the object in view, the vessels are larger, go farther out into deep water, and have on board the conveniences for salting or curing the herrings. Yarmouth is a "red-herring" station, and the arrangements are made accordingly; the boats are of about fifty tons' burthen, manned by about a dozen hands, and provided with about two hundred nets, and with six ropes, each a hundred and twenty fathoms in length. They go to the distance of thirty or forty miles from the shore.

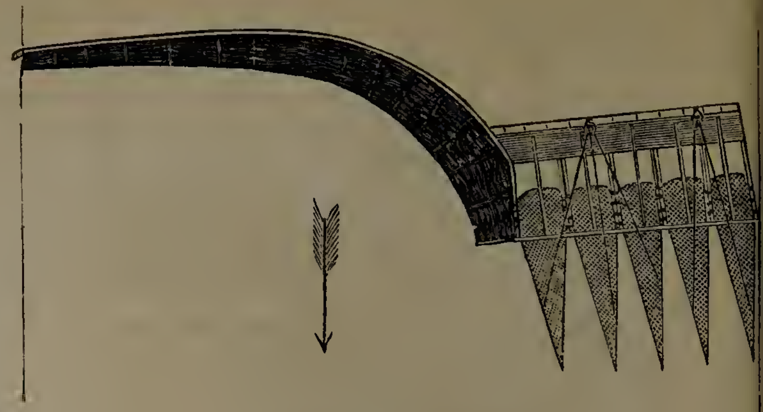
The deep-sea herring-fishery of Scotland is conducted in vessels which ply from loch to loch, and come to anchor in the nearest harbour when the fish appear. Most of the men go out in boats each manned with four hands, for the purpose of setting the nets. Each boat has two trains of nets, about two hundred and forty yards long, and from eleven to twelve yards deep. In deep water both trains are tied together by the back-rope, one end to windward and the other to leeward. The boats are fastened at each end, and allowed to drive to leeward with the nets. Every half hour, or oftener, the men endeavour to ascertain if there are any herrings in the net. This they do by following along the line of the back-rope, and here and there raising a piece of netting. By this means they not only find when they are upon good fishing-ground, but even whether the herrings swim high or low; and they raise or sink the nets accordingly, by shortening or lengthening the buoys by which the nets are kept up. Sometimes they traverse ten or twenty miles in a night, setting their nets ten or twelve times in different places. The fishing is only conducted in the night, and the darkest nights are the best. In the morning, at daylight, the fishermen take their cargo to their respective vessels. When the herrings are in great numbers, the labour is comparatively light; for the nets are set in the evening, and are not hauled up until morning, the men sleeping during the night in the vessel.

The processes to which herrings are subjected after being brought on shore (those at least which are not eaten in the fresh state) are briefly the following:—They are first sprinkled with salt in the vessel; then sprinkled with a further quantity on shore; then washed and spitted, or hung on slender rods of fir; then hung up in regular stages, tier above tier, in a large building; then exposed for three or four weeks to the smoke and heat of a fire made of green wood; then unhung, unspitted, and packed closely in barrels: the finest kind constituting "Yarmouth bloaters," and the rest common "red-herrings." The "salt-herrings" so much eaten in Scotland are prepared simply by being salted and barrelled while the vessel is out at sea.

Other kinds of Fishing.

The use of the *net*, in different forms, is the customary mode of catching most of our market-fish. Thus

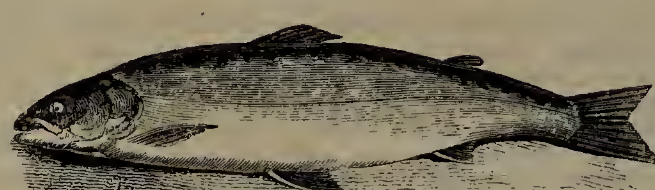
140.—Fishermen selling Mackerel, by Dutch Auction, on the beach at Hastings.



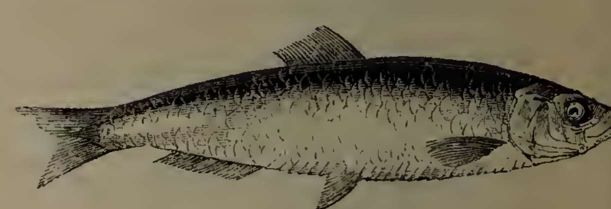
136.—Stage-net, for Salmon-fishing.

143.—Oyster-dredger.

142.—Fishing with Birds, in China.



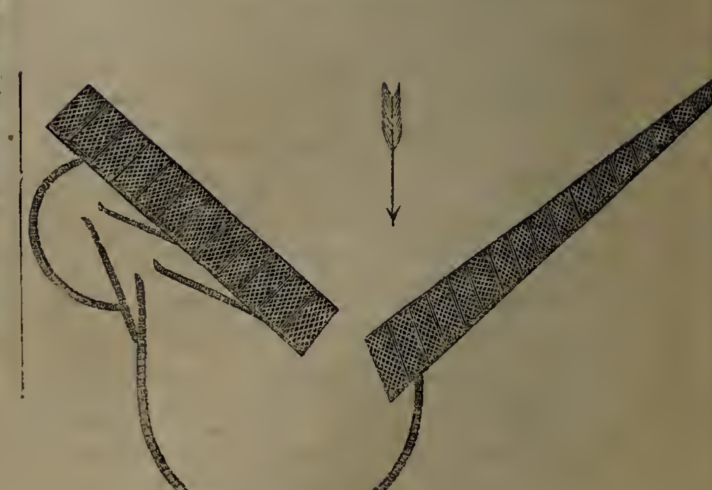
135.—Salmon.



141.—Sprat.

139.—Salmon-spearing, by Torchlight.

138.—Spearing, or Stream-fishing, for Salmon.



137.—Stake-net, for Salmon-fishing.

148.—Fish-woman of Aberdeen.

149.—Fish-bark, or floating Fishmonger's Shop, on the Neva at St. Petersburg.

147.—Fishing Implements: New Zealand.

145.—Crab-Fishing: Fishermen examining their Creels or Crab-pots.

144.—Implements employed in Crab-fishing. *a*, Crab-pot; *b*, Lobster-pot; *c*, Well-box.

146.—A Shrimper.

the *sprat* (Fig. 141) is caught in immense quantities, off the coasts of the south-eastern counties, either in the same way as mackerel, or with a peculiar form of net called the "stow-boat net." The same may be said, with minor modifications, of several other kinds of fish. On the other hand, some of the flat-fish, such as *turbot*, are caught by lines, or by a peculiar combination of lines called "trolling," or "trawling."

There are three familiar kinds of fish, however—*oysters*, *crabs*, and *shrimps*—which may need a little separate notice, from the modes of fishing adopted in respect to them. Oysters are transplanted to a kind of nursery, called "beds," there to lie and fatten. Being enclosed in shells, their habits and their mode of capture are wholly different from those hitherto spoken of. "Brood," or young oysters, of a size not exceeding a penny-piece, are obtained from various parts, and carefully placed on beds in shallow water. The "native oyster" beds near Milton, in Kent, are the most celebrated in England for the quality of their fish; and these beds are generally held on lease by a copartnery, consisting of a considerable number of individuals. The right of fishing within the manor of Milton is enjoyed by a company called the "Free Dredgers," governed by rules and by-laws agreed upon at the court-baron of the manor. The oysters fatten and improve in flavour rapidly when placed on the spots best fitted for them; and when the proper season arrives, they are fished up by *dredgers* (Fig. 143). As the beds lie within a comparatively small space, many boats are congregated near each other, each one manned with two men. The dredge, of which each boat has two, is about eighteen pounds weight, and is used from the side of the boat.

Crabs, as caught for market, are fished in the following manner:—two men go out in a boat containing *creels* or *crab-pots* (Fig. 144), which are made of dry osier, and resemble basket-work; they are constructed on the same principle as a mouse-trap, but the aperture, instead of being in the side, is at the top. Within the creel a bait, consisting of pieces of thornback or skait, is fastened at the bottom, and the creel is then dropped in some favourable situation, three stones of sufficient weight being fastened in the inside to sink it. The creels are sometimes sunk to the depth of twenty fathoms, the fisherman being guided in this respect by the state of the weather or the nature of the ground. A line is fastened to the creel, and at the upper end of the line a cork is attached, which floats on the surface; by which means the place where the creel is sunk is known to the fishermen, who usually set from forty to fifty creels at one time. The crabs, seeing the bait in the creel, enter at the aperture, and, like the mouse in a trap, find that egress is impossible. Lobsters, prawns and shrimps, are often found imprisoned with the crabs. When the creels have been placed a few hours, the fishermen visit them (Fig. 145), and, examining them one by one, take out the captured crabs. They are afterwards brought to market in the well-boxes seen in Fig. 144.

Shrimps, which abound near Gravesend, Lynn, Boston, and a few other places, are caught in nets, used either by persons who wade up to their knees in water, or by fishermen who go out in a boat. Women and even children (Fig. 146) often pursue the simpler plan. The mouth of the net is stretched out by a transverse piece of wood, to which a pole is affixed, the end of which is placed against the breast; and in walking forward, the ledge of the part to which the net is fastened is pushed along the ground, and the shrimps in endeavouring to escape are caught in the bag of the net. The boats which are used by the fishermen are sometimes of several tons burden, and they proceed farther from the shore: they throw out three or four nets, which are made to drag on the bottom by means of leaden weights; so that the principle of both modes is the same.

Fishing-Implements.

These few examples will suffice to illustrate the mechanical arrangements connected with fishing as an industrial art—with the exception perhaps of the whale-fishery, which will engage a little of our attention in relation to another subject. Many branches of trade owe their existence to these arrangements. For instance, the fishing-net manufacture is largely carried on, especially in Scotland, where large factories are devoted to it. The implements for angling, such as the rod, the line, and the hook, are less important commercially, but more choice and particular in an artistic point of view. No one but a disciple of Izaak Walton can conceive the nicety and accuracy which a true angler requires in his implements: the rod is made of wood especially selected for its qualities; the lines are made of gut, many of which are brought from Italy and sold at a high price; the hooks, apparently so small and insignificant a part of the apparatus, have given origin to renown and honour in connexion with the names of certain skilful makers, such as O'Shaughnessy of Limerick, and Kirby of London. When we find that not only such men as Walton and Cotton, but that Sir Walter Scott and Sir Humphry Davy found pleasure in descanting on the merits of these little appendages to the angler's stock in trade, we see that glory may be derived even out of a fish-hook.

In every maritime country, whether savage or civilized, we find that the making of implements for fishing forms one department of industry. Thus, the New Zealanders have much mechanical skill in the production of fishing-hooks and tackle from bone (Fig. 147); and the same may be said of most of the South Sea Islanders.

It may seem odd to class *birds* among fishing-implements; yet if we glance at one of the customary usages in China, we shall find that fishing by means of birds (Fig. 142) will justify the expression. The cormorant, an aquatic bird of China and other countries, is an excellent swimmer and diver, and also flies well. It is very voracious, and as soon as it perceives a fish in the water it darts down with great rapidity, and clings its prey firmly by means of saw-like indentations on its feet. The fish is brought up with one foot, the other foot enables the bird to rise to the surface, and by an adroit movement the fish is loosened from the foot and grasped in the bird's mouth. Le Comte, an old French writer, describes the mode in which the Chinese avail themselves of this angling propensity on the part of the cormorants. "To this end," says he, "cormorants are educated as men rear up spaniels or hawks; and one man can easily manage a hundred. The fisher carries them out into the lake, perched on the gunnel of his boat, where they continue tranquil, and expecting his orders with patience. When arrived at the proper place, at the first signal given, each flies a different way, to fulfil the task assigned it. It is very pleasant on this occasion to behold with what sagacity they portion out the lake or the canal where they are upon duty. They hunt about, they plunge, they rise a hundred times to the surface, until they have at last found their prey. They then seize it with their beak by the middle, and carry it without fail to their master. When the fish is too large, they then give each other mutual assistance: one seizes it by the head, the other by the tail, and in this manner carry it to the boat together. There the boatman stretches out one of his long oars, on which they perch; and being delivered of their burden, they then fly off to pursue their sport. When they are wearied he lets them rest for a while; but they are never fed till their work is over. In this manner they supply a very plentiful table; but still their natural gluttony cannot be reclaimed even by education. They have always, while they fish, the same string fastened round their throats, to prevent them from devouring their prey; as otherwise they would at once satiate themselves, and discontinue the pursuit the moment they had filled their bellies."

Fish-Trading.

There are many original peculiarities among those who are engaged in fishing or vending fish, arising from the nature of their employment. A fisherman has been a favourite actor in novels and romances, as well as in more sober productions, from the earliest times; while the venders of fish have their own stamp of oddity. Mr. St. John, in his 'Manners and Customs of the Ancient Greeks,' has collected many humorous passages from the classical writers relating to the quickness, the wit, and the knavish cunning of the itinerant fish-dealers of Athens; so much so, indeed, as to remind us strongly of what passes in the streets of modern London. A Billingsgate fish-woman needs no description for any one who has seen much of the metropolis: she defies criticism, and—everything else. The "fish-wives" of Edinburgh are equally marked for their characteristic appearance, manners, and mode of life. So likewise are those of Aberdeen, one of whom (Fig. 148) may represent the class. There is a part of Aberdeen called the "Foot Dee," or the "Fittie," inhabited almost exclusively by fishers and fish-venders; a class so distinct from the rest of the inhabitants, that the one class can only just understand the language of the other. Of these fish-people a writer in the 'Westminster Review' says: "The 'Fittie-folk' scarcely ever intermarry with the other citizens; their marriages are generally penny-weddings. They seldom send their children to school, and almost never to a promiscuous one. Their sons are almost invariably brought up to follow the occupations of their forefathers, and never learn any regular trades; except that perhaps now and then a youth, more adventurous than usual, becomes a ship-carpenter. They live together patriarchally, sometimes three or four generations in a single room. The oars are laid above them in the couples or rafters of their cottages; the children may be seen sleeping on nets in corners; and on the walls are creels, baskets, and other fishing-tackle. Their boats descend by primogeniture. Their women have not merely a costume different at all times from that of women in a similar rank of life in Aberdeen (distinguished by an all but exclusive preference for the colours white and blue, and consisting generally of a blue striped wrapper, blue baize petticoat, and close cap, called a *toy-much*, with *moggins*, or stockings without feet, and they wear no shoes); but they also adopt very generally the masculine blue jackets of their husbands and brothers. The men do little more than go out with the boats. The women search for bait, assist in carrying the nets, bait the hooks, and do all drudgery, while their lords are looking on with folded arms. . . . The women, both of Foot Dee and those of the same race in several other villages on the east coast of Scotland, carry great loads of fish to market on market-days in creels (large wicker baskets, which are fastened to their shoulders and rest on their hips), sometimes as many as eleven miles before breakfast; and so necessary does the load become to them to enable them to walk steady, that when they are returning home they prefer carrying stones to carrying an empty creel. They never walk but in single file; and they have a superstitious dread of being counted, a fear of which the boys of Aberdeen avail themselves to annoy them by crying as they pass,

> 'One, two, three:
> What a lot of fisher-nannies I see!'"

The fish-trading arrangements of different towns depend on a large variety of circumstances, of which temperature is one. At St. Petersburgh, for instance, where the fish are frozen as hard as a board during winter, they are sold in floating shops (Fig. 149) during the brief summer season. These barks are moored on the Neva, near the quays; and each one is surrounded by numerous cisterns and boats, either pierced with small holes to admit the clear fresh waters of the Neva, or filled with salt water for sea-fish. The matrons and housewives who "go to market" step along the railed plank which leads from the quay to the floating shop, accompany the fishmonger down the sloping plank to his reservoirs of fish, and bargain for such fish as may meet their wants; having usually a *dvornick*, or servant, to carry home the purchased fish.

CHAPTER II.

THE ARTS RELATING TO THE SUPPLY OF WATER, FIRE, AND LIGHT.

It would be vain to attempt to determine, among all the arts of industry, which are the most urgent in respect to our every-day wants, which may be laid aside till others are provided for, and what is the order of arrangement in relative importance. So multifarious are the demands made on our ingenuity, and so sure is every—even the slightest—advance in civilization to create new wants, that those things which are deemed *luxuries* in a rude state of society, become *conveniences* in a more advanced stage, and are ultimately regarded as *necessaries*. Not only are new links being constantly added to the chain, but the chain itself assumes a different form. Each generation in a country, where the development of its resources has fair play, starts from a higher point than the preceding one, and has a stock in trade to begin with, in the march towards improvement. It would be well if the complainers (a rather numerous class at all times) could compare an *average* English house (for extremes, either above or below the average, never properly illustrate a case) at the present day, with the average three or four centuries back: it would be found that in the clothing, both as to neatness and cleanliness; in the conveniences for dressing and preparing food; in its "cheerful fire-side," with all the little useful appendages; in its window-arrangements by day, and its light-arrangements by night; in its facilities for preserving cleanliness of person and of house; in its vessels and baskets, its drawers and cupboards, its recesses and shelves, and all the little aids for ensuring "a place for everything, and everything in its place"—in all these points an English house at the present day possesses an immeasurably larger amount of comforts, or conveniences, or necessaries (call them which we may), than a house of analogous rank in past times.

The *necessaries* of life are thus a relative term, subject to frequent change of meaning; and we need not spend much time in deciding the exact order of precedence in the industrial arts connected with them. But we shall not go far wrong, after having, in the First Chapter, rapidly glanced at those pertaining to the supply of food, if we next pass in review the various modes which ingenuity and skill have devised, in different countries, and at different times, for ensuring, day by day, a supply of *water*, of *fire or warmth*, and of artificial *light*—three wants, varying in urgency according to circumstances of time and place, but all urgent in a very high degree, as every one will admit.

SUPPLY AND DISTRIBUTION OF WATER.

We shall find that, however different the modes of procuring water for drink or for domestic purposes may appear to be, the source of the supply is a *river*. All fresh-water lakes derive their waters from rivers which flow into them, and all springs are fed from the rain which falls on the surface of the ground, which rain results from the condensation of the moisture evaporated from rivers, lakes, and seas; so that there is a continued circuit going on, in which dry land, streams, and the atmosphere, successively act their part. The modern contrivance of "Artesian wells" beautifully illustrates this movement; but it will be well to defer the consideration of them until more simple matters have been noticed, such as the

Wells and Water-carriers of the East.

From the earliest times the digging of wells has been an important circumstance in the flat sandy districts of the East. In many places there is no trace of anything like a river for scores or hundreds of miles; and under such a privation only two resources present themselves—either to dig downwards in the earth until a watery stratum is met with, or to transport water from other places. The latter is the *aqueduct* system, of which we shall presently speak; while the former gives occupation to some among the many varieties of water-carriers in the East.

In the Bible the allusions to wells are numerous, and in those districts which were not adjacent to any river, the preservation of the wells so dug was regarded as a matter of first-rate importance. Mr. Kitto, in his work on Palestine, says:—"To dig a well is, unless under very peculiar circumstances, the most arduous and important work which a person in such situations (pitching a tent in an arid country) undertakes; and the benefits of such a work are so highly appreciated, that the property of it becomes vested in the person by whom it was dug, and in his heirs for ever. While his clan are encamped near it, no parties not belonging to him can draw its waters without his leave."

The physical configuration of a country is obviously one of the most important features in respect to the supply of water. Thus there is scarcely any other country in the world so ill provided with large streams as Persia; and the inhabitants therefore collect with the more care the water which flows in small rivulets from the hills. There is a distinguished officer of government in every province, who has the charge of the conveyance and distribution of water. Deep and broad wells are dug, out of which the water is drawn in large leather buckets, by means of oxen; the contents of the buckets are emptied into cisterns, and from the cisterns are distributed among the inhabitants.

Whoever has read the narratives of intelligent travellers in the East must have had abundant means of observing the shifts to which not only travellers, but often the inhabitants themselves, are put, in consequence of not having a supply of fresh water at hand; the wells being far away from their abodes. When Forster was travelling in Persia, he put up at a caravanserai in Turshish, and lodged with a stranger on terms of mutual accommodation. "It was agreed," he says, "that a joint board should be kept; that my associate, yet weak from a late sickness, should prepare the victuals; and that I should furnish the water—and a laborious duty it was, there being no good water at a nearer distance than a mile. Here I must inform you that this was by no means a degrading duty, and is performed by travellers of a rank much superior to that I held."

The conveyance of water from a river across a sandy desert to an encampment, or the retailing of water by itinerant dealers, gave rise to the use of portable vessels suitable to the object in view; and many Oriental countries, down to the present day, exhibit some such persons, vessels, and scenes as are sketched in the next eight cuts (Figs. 150 to 157). In some few cases the vessels used are of earthenware; but as these are hard and unyielding, and in that respect somewhat difficult to carry, a curious substitute has been adopted instead of them. These are skins of goats and other animals, prepared in a rude way, and fastened where necessary. The Arabs sometimes make use of water-bags made of tanned camel-skin; but the skins in most general and diversified use are those of the goat and kid. The bucket with which they draw water from deep wells is also made of leather; and not only their water, but their milk, butter, cheese, dates, and other articles of provisions, are carried and retained in skins. Such vessels are not only more portable and less liable to damage in travelling than any other kind of vessel obtainable by the wanderers of the desert; but the Arabs think that the articles are thereby kept in a state of greater freshness. The larger kind of water-bag is most usually the skin of a he-goat; while one from a kid is used as a bottle for occasional purposes during a day's journey, hanging suspended from the saddle. The most common sort make a curious appearance when full of water, resembling an animal of which the head and feet have been cut off. The manner in which the Arabs obtain these water-bags, or bottles, is very simple: when the animal is killed, its head and feet are cut off, and the carcass is drawn out of the skin without the belly being opened. It will be seen from many of the figures, that the pliable nature of the skin-bottles enables them to be carried very conveniently on the back, bending round to the front over the shoulder, or under the arm.

Mr. Lane's account of the proceedings in Egypt relating to the retail supply of water is curious and interesting. As the water in the Cairo wells is slightly brackish, the townspeople are supplied with the water of the Nile by three classes of itinerant dealers, the *sack'ckas*, the *sack'cka shur'behs*, and the *hhem'alees*. During about four months of the inundation season, the *sack'ckas* draw water from the canals in connexion with the Nile, and carry it in skins, sometimes carried by the men themselves, but generally by camels or asses (Fig. 150). The water-skins borne by the camels are a pair of wide ox-hide bags; while those carried by the asses are made of goat-skin. These men have generally one cry—"*Yá ow'w'ud Allah*"—"May God compensate (me);" and when this cry is heard, the townspeople know that a *sack'cka* is passing by. For a goat's-skin of water, brought from a distance of a mile and a half, or two miles, he obtains scarcely more than a penny. Of those who supply water to passengers in the street, some are called *sack'cka shur'behs* (Fig. 156). The water-skin carried by them has a long brass spout, and they pour the water into a brass cup for their thirsty customers. The *hhem'alees*, a more numerous class, who are mostly durwee'sshees (or dervishes, to use a more familiar mode of spelling), carry vessels of a fine grey earth on their backs (Fig. 154). They are a kind of privileged class; they *exact* nothing for the beverage, depending on the will of the drinker for remuneration.

In the districts of Africa southward of Egypt, the same system of carrying water in skin bottles is observable, and has been described by travellers. Thus Browne, in his 'Journey to Dar-Fur,' says—"The water, in leaving Egypt, is commonly conveyed in goat-skins, artificially prepared; but no skill can entirely prevent evaporation. On their march from Soudan to Egypt, the Jelabs oftener use ox-hides, formed into capacious sacks, and properly secured with tar or oil. A pair of these is a camel's load. They keep the water in a better state for drinking than the former; and these sacks are sold to great advantage throughout Egypt, a pair of the best kind being worth thirty piastres. They are the common instruments for conveying water from the river to different parts of each town. The camels are not allowed to partake of this store, which, after all the care that can be taken of it, is often very nauseous, from the tar, the mud which accompanies the drawing, heat, &c. Six of the smaller skins, or two of the larger, are generally esteemed sufficient for four persons for as many days."

In many of the less civilized countries the natives often use some kind of vegetable substance of large size, and capable of being hollowed within, as a water-vessel. The New Zealanders, for example, make use of the calabash, the fruit of a tropical plant, as a drinking vessel (Fig. 158); holding the vessel some distance above the head, and allowing the water to flow down in a stream into the mouth. This is, however, an illustration rather of a rude kind of drinking-vessel, than of a vessel for the conveyance of water from place to place.

Without dwelling more on this point, we may next proceed to notice the

Aqueducts and Fountains of early times.

These structures, by far the most striking and costly of all the arrangements connected with the supply of water, exemplify one of the modes of conducting a stream of water from a spring or river to a town, across an intervening district which does not furnish the requisite supply. Looking at such aqueducts as those shown in Figs. 159, 160, 161, it will be seen that they contribute in a remarkable degree to determine the character of the scenery presented by a district. In England we have nothing like them, except perhaps the viaducts of some of the railways; but a tourist in any of the countries once occupied by the Romans, will meet with many examples of them.

The industry of that extraordinary people may be judged from the means which they took to supply their capital with water. The supply was obtained from sources varying from thirty to sixty miles distant; and at one time there were no fewer than twenty aqueducts, bringing as many different streams of water across the wide plain or Campagna in which the city stands. During some portions of the distance there were artificial channels winding along the sides of hills and mountains; in another portion of the distance long tunnels were excavated through these natural barriers; but there were covered ducts or channels to convey the water across the deep valleys; and an aqueduct was in every case required to carry it onwards from the hills over the wide plain to the city.

These aqueducts were for the most part built of brick, and consisted of square piers, connected by semicircular arches, having a channel or course at the top for the flow of the water. Whatever were the inequalities of the ground, the piers were built to such a height as would give a regular but very gradual descent to the water. The conduit or water-channel had a paved or tiled floor, and was enclosed laterally by walls of brick or stone, and covered with a transverse arch, or by a simple flat coping of stone. There were frequently serious difficulties to encounter; for if the source of the water were much higher than the place at which it was to be delivered, and the distance too short to reduce the flow to a moderate velocity, the stream had to be carried in a winding direction, to

150.—Sack'ckas, Water-sellers of Cairo.

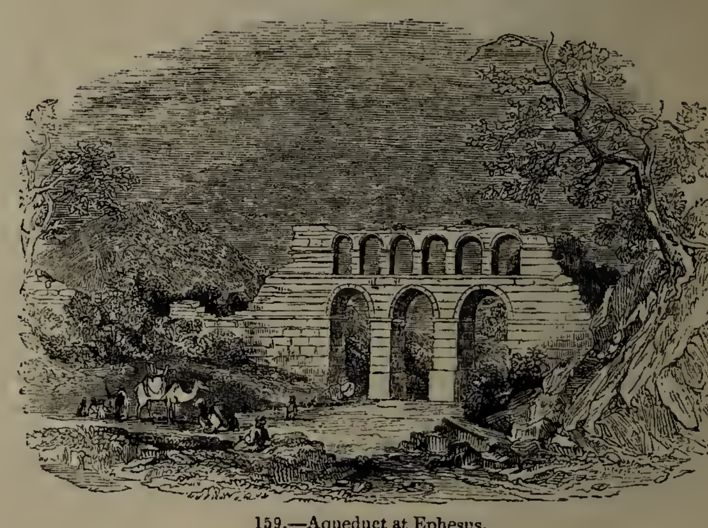
151.—Skin Water-bottles of the East.

158.—New Zealander drinking from a Calabash.

153.—Egyptian Water-carrier.

152.—Skin Vessels of the Arabs.

154.—Hhem'alees, Water-sellers of Cairo.

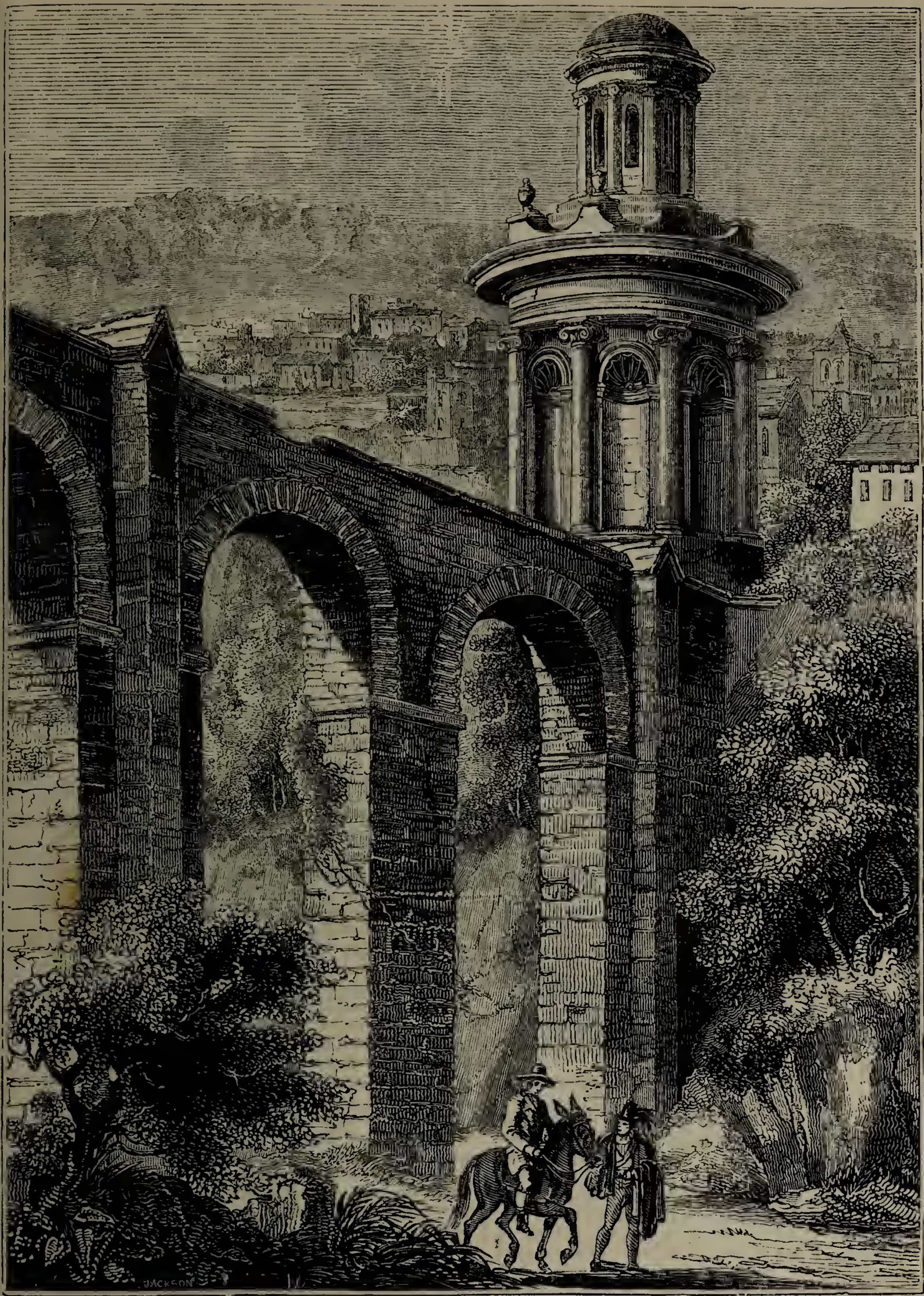


159.—Aqueduct at Ephesus.

155.—Arab Bottles and Water-carriers.

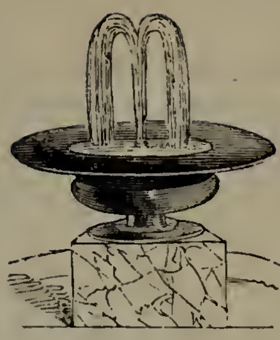
156.—Sack'cka Shur'beh, Water-seller of Cairo.

157.—Skin Vessel.

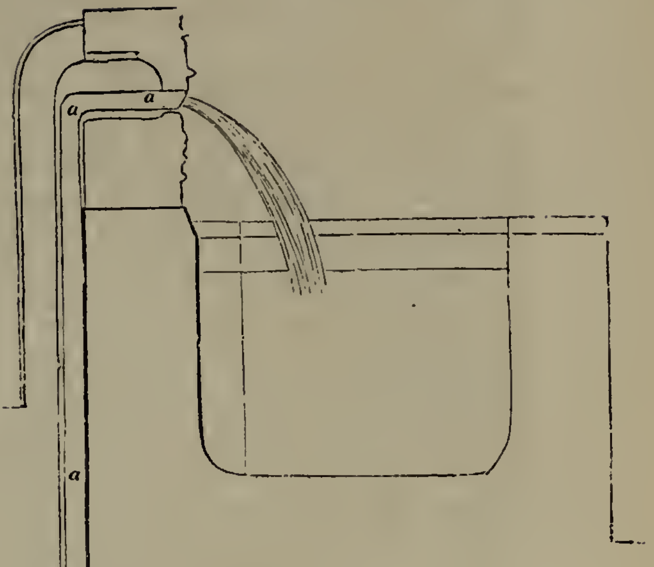


160.—Roman Aqueduct and Castellum at Evora, in Portugal.

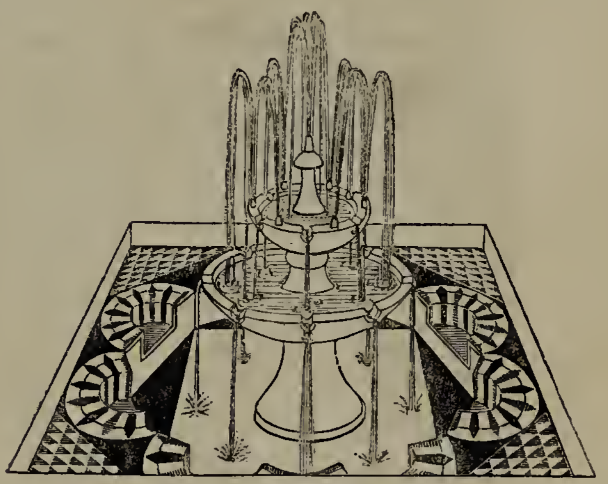
161.—Moorish Aqueduct at Elvas, in Portugal.



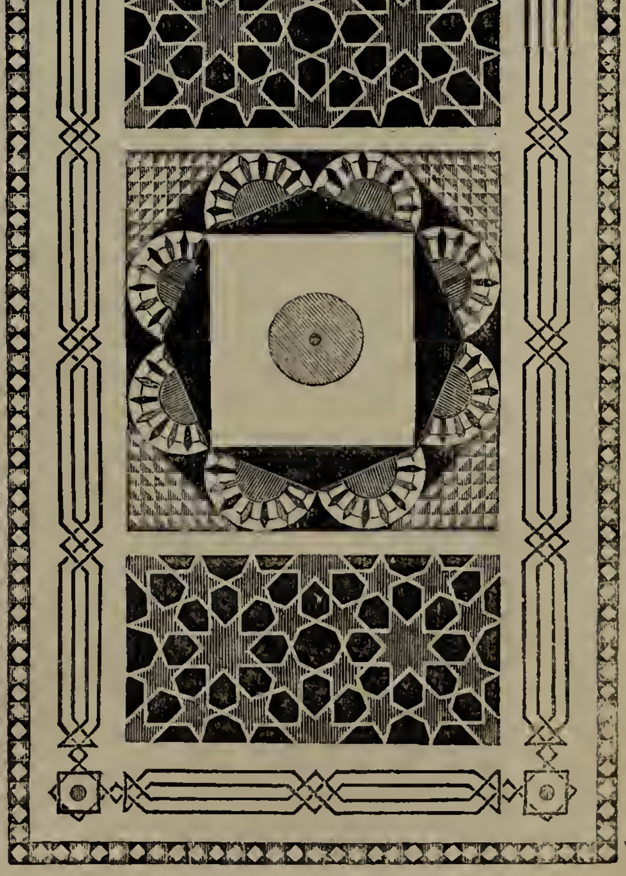
163.—Fountain. (Fom the paintings of Pompeii.)



162.—Section of Fountain, from Pompeii, showing the ascending-pipe, *a*, *a*, *a*.



164.—Egyptian Fountain.



165.—Tessellated Pavement of Egyptian Fountain.

expend the height in a greater length; if this were not done, the pressure of the water would have burst the covering of the aqueduct, and the whole country over which it was carried would have been inundated. In this way were the mighty structures formed which brought water into Rome—the Aqua Martia, for a distance of forty miles on a series of arches seventy feet high; with the Aqua Julia and the Aqua Sepula occupying two higher levels on the same aqueduct, the whole three forming a triple series of arches one above another; the Aqua Claudia, extending thirty-six miles beneath the ground, then eleven miles on the surface, then in a continuous vault for three miles, and then on lofty arcades for seven more;—and other noble specimens of skill.

It was not only in Rome that these aqueducts existed; for the Romans supplied all their more important cities, in Greece, in Gaul, in Spain, in Italy, and in Sicily, by similar means. In connexion with the aqueduct at Evora (Fig. 160) is seen a castellum or sort of tower; and such places were often constructed on the Roman aqueducts. They were erected at certain distances from each other as lodging-places for soldiers, who were charged with the protection of the important works of the aqueduct. Some of them were also occupied by masons and builders constantly at hand to keep the aqueducts in repair; while others merely served as fountains or conduits where the water could be procured and drawn off by means of pipes and cocks. The Castellum at Evora is of this kind; in the interior of it there is a reservoir to hold part of the water conveyed along the aqueduct, and some pipes emit this water on the spot, while other tubes convey the water underground to different fountains and cisterns within the town. By far the greater number of the Roman aqueducts on the Continent have been neglected and allowed to go to ruin in modern times; but this one at Evora is well kept up; for eighteen hundred years the inhabitants of the town have been supplied with water by this aqueduct. The aqueduct is built of stone cemented with hard marble-like mortar.

The aqueduct at Elvas (Fig. 161), though in the same country as that at Evora, is of later date, and was constructed by a different people. The Moors, by whom Elvas was enriched with many remarkable specimens of engineering and of architecture, constructed this aqueduct. It conveys the water of an excellent spring, for the distance of about fifteen miles, to the city, where an immense reservoir is kept constantly filled, containing sufficient for the inhabitants for six months. Most aqueducts are carried as near as can be in a straight line; but that at Elvas forms an irregular zigzag somewhat resembling the representations of a flash of lightning—this arrangement being necessary on account of the peculiar formation of the ground over which it passes. The aqueduct consists of four stories or tiers of arches; the lowest tier nearly a hundred feet in height, the uppermost forty feet, and the whole together reaching to a height of two hundred and forty feet. This vast altitude, for a continuous range of arches, may be better conceived when we consider that it exceeds by nearly fifty feet the height of the Monument at London Bridge! The valley which this stupendous erection crosses is about a mile and a half wide, and consequently involves a most immense amount of building and masonry. The aqueduct is supported at intervals by large buttresses, some triangular, some square, and some round, with stories decreasing in size as they approach the top.

As in the Western Empire, so in the Eastern; the aqueducts constructed by the Romans still give a beautiful and picturesque appearance to the districts where they are situated. There are some aqueducts not far from Constantinople, of which Miss Pardoe thus speaks in her 'Beauties of the Bosphorus.' After alluding to the comparative neglect of these aqueducts by the modern Turks, she says:—"But they were not allowed, nevertheless, to supersede them altogether—a fact which must gratify every lover of the picturesque as he gazes on the majestic aqueduct of Validé, which is flung across the fair valley of Buyuk-dère, terminating the vista as seen from the Bosphorus, and linking the heights with a range of many arches. Another, of more vast but perhaps less graceful proportions, and certainly less happily situated, is that of Solyman near Pyrgo; it dominates a valley a thousand six hundred feet in width, is formed by a double range of fifty arches, and is of very imposing appearance, and constructed with great solidity. The aqueduct of Valens is one of the most striking objects that meet the eye of the stranger as he gazes enraptured on the far-famed city of the Bosphorus. Dark, and hoar, and massy, it links two of the seven hills, and spans the peopled valley with a giant grasp; in strong contrast to the gaiety and glitter of the marble mosques and party-coloured houses. Festoons of the graceful wild vine and the scented honeysuckle drapery its mouldering masonry; masses of the caper-plant, with its beautiful blossoms, conceal the ravages of time; lichens trail among its arches; and a variety of stone-plants, fed by the moisture which is continually oozing through the interstices of the building, flourish in picturesque luxuriance, and lend a glory to its decay."

This transference of water from hills in the distance to the precincts of a busy town or city, was of course accompanied by an arrangement of fountains, of cisterns, or reservoirs to aid in the distribution of the water to the inhabitants. At Rome (according to the account given in the volumes on 'Pompeii' in the 'Library of Entertaining Knowledge') the system was managed in the following manner:—The proper distribution of the streams which flowed through the aqueducts was intrusted to the supervision of an officer of high rank. The letting out of the public water to private persons was a source of revenue; and there were many precautions for the frustration of fraud in this matter. The aqueducts were each charged with a certain number of supply-pipes; and no new pipe could be inserted without a special application to the emperor. Permission being obtained, the overseer assigned to the applicant a *calix*, as it was called, of the assigned dimensions. This was a brass measure fixed in the castellum or reservoir, the diameter of which regulated the quantity of water which could pass through it. It was ordered to be made of brass, that it might not easily bend, and that there might be less liability of fraud, either in the public or the individual, by enlarging or diminishing the prescribed aperture. Beyond the calix the pipe was private property; but, more effectually to prevent fraud, it was enacted, that for fifty feet from the calix the pipe and it were to be of the same dimensions; and to prevent the breaking up of the public pipes, it was expressly provided that every person should draw water from one of the castella or reservoirs in which the aqueducts terminated. The right to a supply of water was strictly personal, not attached to houses, so that the supply was cut off at every change of ownership. The right of water which had once been granted was sold by the superintendents, at every change of ownership, to the highest bidders. Those inhabitants whose means of interest were insufficient to obtain a private pipe, were obliged to fetch water from the public fountains.

In other cities of the Roman empire, besides the metropolis, there were fountains for the distribution of the water brought by the aqueducts or by other means. Thus, at Pompeii, some of the public fountains have been discovered in a state almost perfect, evincing by their construction the knowledge which the ancients possessed of the property of water to rise to its level. In Fig. 162, for example, a section of one of the Pompeiian fountains exhibits the course of the ascending pipe which conveys the water into the tank or reservoir; while Fig. 163 shows that the constructors were acquainted with the mode of producing the "jet d'eau" so conducive to the ornamental appearance of a fountain.

There were fountains, or rather reservoirs connected with the aqueducts at Constantinople of a most extraordinary character. One of these, still in existence, was a public reservoir, at which every one might serve himself: it was supported by nearly four hundred pillars of hewn marble, and was capable of holding nearly a million and a half cubic feet of water. Another, smaller in size, is much handsomer than this first. But the third is by far the most wonderful of the three. It was re-discovered about three centuries ago, after having remained concealed for ages. It is an underground cistern, or "hall of waters," as the Turkish name signifies, always containing water varying from five to fifteen feet in depth. Its roof is supported by marble columns, each wrought from one single block of marble. Many attempts have been made to traverse the surface of the water in this cistern in a boat; but it is not known that the attempt has ever succeeded; nor have the dimensions of the giant reservoir, or the mode in which the water gains entrance to it from the aqueducts, been clearly determined.

Fountains and Conduits of modern times.

In transferring our attention now to the productions of later ages, in respect to the modes of distributing a supply of water among the inhabitants of a town, we shall find that there is great diversity, according to the nature of the country, the habits of the people, and the reliques of former arrangements. Thus many countries in which the Romans have erected aqueducts still make use of those noble monuments of art; but in almost every case of more modern origin, with the exception of the Croton Aqueduct at New York, the arrangements are much less costly than in the time of the Roman Empire.

We have seen that in Egypt and the neighbouring countries water is carried by itinerant dealers from springs and rivers to the houses; and from Mr. Lane's description of the interior arrangements of the better class of dwellings at Cairo, we find that there are means adopted for obtaining the cooling play of a fountain in a particular apartment or court of the house. There is on the ground-floor an apartment in which male visitors are received, having a door or window in connexion with the open court of the house. A small part of the floor, extending from the door to the opposite side of the room, is six or seven inches lower than the rest. This sunken part, which is called the *doorckà' ah* (Fig. 164), is often paved with black and white marble, and little pieces of red tile, inlaid in complicated and tasteful patterns, of which Fig. 165 is an example. In the centre there is a fountain, which plays into a small shallow pool lined with coloured marble and tiles like the surrounding pavement. The water which falls from the fountain is drained off from the pool by a pipe.

In Turkey there is a curious intermixture of systems in respect to water-supply; for while the ancient aqueducts still remain as monuments of past times, the industry of a later age has provided less costly but still very efficient means. Among the hills at some distance northward of Constantinople are large reservoirs called *Bendts*, in which the water is collected from all the surrounding districts. By throwing up mounds and embankments, and building walls and sluices, the water is preserved in these reservoirs in large quantity and great purity; and severe penalties are enforced against all those who damage any of the arrangements. The water from these reservoirs is conducted to Constantinople by a system midway between the old and the modern methods, partaking somewhat of both. Pipes, formed of cylindrical tiles jointed together, are laid down along the whole distance, extending in one instance to fifteen miles; these pipes are conducted over valleys, through hills, and across streams, so as to give a gentle and uniform declivity to the whole. At certain intervals there are hydraulic towers, called *souterrais*, which bear some analogy to the syphons in the reservoirs of English water-works; for the water ascends one side of each tower, up to a small reservoir at the top, and descends on the other. Each tower is a few inches lower than the one next preceding it; so that, on the one hand, the water has ascensive power enough to reach the top of the tower; and, on the other, this ascent gives to it sufficient moving force to ascend the next following tower.

When the water has been thus conveyed into the city, it is distributed to the different quarters by means of fountains, many of which are very beautiful (Fig. 166), covered with elaborate arabesque ornaments. Fountains stand by every mosque, for ablution before prayer; and most of them have neat drinking-vessels at hand for supplying the wants of the thirsty traveller. The Turks deem the best of all charities to be an abundant supply of water; and they certainly must be said to adopt praiseworthy means to carry out this principle.

Modern Rome is one of those cities which have to thank past ages for this most salutary of civic arrangements. So excellent was the plan on which the aqueducts of the Empire were constructed, that even the ruins of them enable modern Rome to be supplied with water better than almost any other city on the Continent. Three of the ancient aqueducts yet remain, and carry an abundant supply of water into the capital; the successive popes having exerted their authority to keep these three in repair. The first of these is the *Acqua Virgine* (to call it by its modern Italian name), which comes from near the ancient Collatia, fourteen miles north of Rome; it supplies a great part of the lower town, and feeds thirteen public fountains. The second is the *Acqua Felice*, which comes from the east for the supply of the upper or eastern part of the town, and feeds twenty-seven public fountains. The third aqueduct, called *Acqua Paolina*, enters Rome near Mount Janiculus, and supplies the houses and the fountains not served by the other two aqueducts. It has been estimated that the supply of water thus conveyed to the city is greater than that furnished to a population six times as great at Paris.

The fountains here alluded to are among the most striking architectural features of modern Rome. The author of 'Rome in the Nineteenth Century' says:—"Nothing strikes a stranger with more just admiration at his arrival at the capital of the world, than the immense number of fountains which pour forth their unceasing flow of waters on every side. It is a luxury, the full enjoyment of which cannot be felt but in such a climate as this; and those only who have known that delicious moment, when the blaze of the summer day fades at last in the golden clouds of evening, can understand the voluptuous delight with which, in its hushed hour of stillness and repose, you listen to the music of their dashing murmur, and rest beneath their freshness." And in another place he adds, "On the whole I admire with fond admiration the fountains of Rome, not that as fountains I think them beautiful; but that falling water in an ample quantity must be beautiful in a climate like this, where its sound, even in winter, is so sweet to the senses. I love to repose my fancy upon the three noble cascades that are poured forth at the Fontana Paolina; the copious streams which burst from the rocks at the Fountain of Trevi; and those silver fountains that throw high in air their glittering showers within the grand colonnade of St. Peter's."

Of the three aqueducts mentioned above as being still remaining, the Acqua Paolina divides itself into two branches, one of which supplies the Fountain of Paul V. ("Fontana Paolina"), the lofty structure sketched in Fig. 167. It was constructed by the architect Fontana, by order of Pope Paul V., with materials taken from one of the ancient forums. Six Ionic columns of red granite support an entablature bedecked

with inscriptions and heraldic insignia. The water rushes in a vast body through the principal openings, and in smaller quantity through orifices in the mouths of dragons which are placed in niches on either side. The water falls into a fine basin of white marble. Eustace, speaking of this structure, says :—" The lofty situation of this fountain renders it a conspicuous object to all the opposite hills : the trees that line its sides and wave to the eye through its arches, shed an unusual beauty around it ; and the immense basin which it replenishes gives it the appearance, not of the contrivance of human ingenuity, but almost the creation of enchantment." He draws rather a satirical comparison between the " splendid and truly imperial style" in which these fountains are conceived and supplied, and the generality of fountains in other countries. " Artificial fountains in general are little better than ornamental pumps, which sometimes squirt out a scanty thread of water, and sometimes distil only a few drops into a muddy basin. Those on a greater scale now and then throw up a column, or pour a torrent, as occasion may require, on certain state days, or for the amusement of some distinguished personage, and then subside till a fresh supply enables them to renew the exhibition. Such are the so-much-celebrated water-works of St. Cloud, Marli, and Versailles; inventions which can be considered only as playthings, calculated, like a theatrical decoration, to act an occasional part, and to furnish a momentary amusement, but too insignificant to be introduced into the resorts of the public."

By comparing Figs. 167 and 172 it will be seen how great diversity of appearance there is in the fountains of Rome. This latter, the Fountain of the Prince of Palestine, was constructed from the designs of Bernini, who designed a great number of the city fountains. It is situated in the Piazza Barberini, and exhibits a triton seated upon four dolphins, and throwing up water from a large shell. Another of Bernini's fountains is in the Strada Navona : it consists of a rock, having at each angle a colossal figure, representing, respectively, the Danube, the Nile, the Danube, and La Plata ; from four caverns in the rock issue an equal number of cascades, pouring forth an immense body of water ; and the summit terminates in an Egyptian obelisk fifty or sixty feet in height.

In respect both to fountains and conduits, our own country has but little to show, and even that little is gradually diminishing among the many changes going on around us. The extension, in most of our large towns, of *water-works*, and the conveyance of the water to inhabited houses by means of pipes laid beneath the streets, have effected the removal of many of the old conduits represented in prints and books of the sixteenth and seventeenth centuries. The merchants and busy traders of London might look long for the two conduits represented in Figs. 168 and 169 ; and yet such were once to be seen in the heart of the mighty city. Westward, too, the Bayswater Conduit (Fig. 170), and, in a northern direction, the old conduit from which " White Conduit House" derived its name—have passed away. In some of these cases, as in many with which our daily experience renders us familiar, the picturesque has yielded to the expedient.

These fountains or conduits, though now superseded by other contrivances, were in their day deemed a great advance on the arrangements previously in use Stow tells us that, anciently, " until the time of the Conqueror, and two hundred years later, this city of London was watered, besides the famous river of Thames on the south part, with the river of the Wells, as it was then called, on the west ; with a water called Walbrook running through the midst of the city into the river of Thames, severing the heart thereof ; and with a fourth water, or bourn, which ran within the city through Langbourn Ward, watering that part in the east. In the west suburbs was also another great water, called Oldbourn, which had its fall into the river of Wells." How difficult is it to persuade ourselves that this " River of Wells" is the too notorious Fleet Ditch of later times ; that the Walbrook, where a pleasant stream ran, is the narrow street where St. Stephen's church is now built ; that the Langbourn, or " long stream," which has given a name to one of the city wards, should have once flowed through Lombard and Fenchurch Streets ; and that the " Oldbourn," flowing into the " River of Wells," is the site of modern Hólborn, terminating eastward at the Fleet Ditch !—Yet such appears to be the case. There were also, as Fitzstephen relates, at Holywell, Clerkenwell, and St. Clement's Well, " choice fountains of water, sweet, wholesome, and clear, streaming forth among the glittering pebble-stones."

These bourns and springs supplied the Londoners with water for a time ; but the increase of inhabitants, and the encroachment of buildings, rendered other arrangements necessary. Henry III. granted a licence to Gilbert Sanford to convey water from the town of Tyburn, through leaden pipes, into the city. The pipes were of six-inch bore : they conveyed the water to Cheapside or Westcheap, where the first conduit was erected. After this, as the wants of the citizens successively increased, other conduits were built, such as the Tonne in Cornhill, the Standard and the Little Conduit in the same vicinity, a more than usually picturesque one in Leadenhall, and one in Shoe Lane. The first of the conduits consisted of a leaden cistern castellated with stone ; and being repaired from time to time, remained still existing at the latter part of the seventeenth century, when it was removed, in consequence of changes planned after the Great Fire.

There is a curious and interesting passage, written about the time of the fearful event just alluded to, in an essay called ' Meditations on the Burning of London,' illustrative of the state of the London conduits at that time. " As Nature, by veins and arteries, some great and some small, placed up and down all parts of the body, ministereth blood and nourishment to every part thereof, so was that wholesome water, which was as necessary for the good of London as blood is for the life and health of the body, conveyed by pipes, wooden and metalline, as by veins, into all parts of that famous city. If water were, as we may call it, the blood of London, then were its several conduits as it were the liver and spleen of that city (which are reckoned as the fountains of blood in human bodies) ; for that the great trunks of veins conveying blood about the body, as great roots fixed in the earth, shooting out their branches divers and sundry ways : but alas ! how were these livers inflamed, and how unfit have they since been to do their wonted office ! They were lovely streams indeed, which did refresh that noble city, one of which was always at work, pouring out itself when the rest lay still. Methinks these little conduits of London stood like so many little but strong forts, to contract and give check to that great enemy fire if any occasion should be. There methinks the water was, as it were, intrenched and garrisoned. The several pipes and vehicles of water that were within these conduits, all of them charged with water, till by the turning of the cocks they were discharged again, were as so many soldiers within the forts with their musketry charged, ready to keep and defend those places. And look how enemies are wont to deal with those castles which they take to be impregnable, and despair of ever taking by storm ; that is, to attempt the starving of them by a close siege—so went the fire to work with those little castles of stone which were not easy for it to burn down (witness their standing to this day) ; spoiled them or almost spoiled them it hath for the present, by cutting off those supplies of water which had wont to flow to them, melting those leaden channels in which it had been conveyed, and thereby as it were starving those garrisons which they could not take by storm..... As if the fire had been angry with the poor old tankard-bearers, both men and women, for propagating that element which was contrary to it, and carrying it upon their shoulders as it were in state and triumph ; it hath even destroyed their trade, and threatened to make them perish by fire who had wont to live by water."

It will be interesting here to compare the arrangements at Paris in respect to water ; since they bear a good deal of analogy to those presented in London in past times—much more so than to London in the present day. But before speaking of the fountains that *are*, let us speak of one which *was to have been*, if the bold plans of its ambitious projector had been carried out. We allude to the " Fountain of the Elephant " at Paris, of which the design is sketched in Fig. 171. This fountain, intended by Napoleon for the embellishment of his capital, was to have been erected on the site of the ancient Bastille. The decree for its erection was dated February 9, 1809 ; and the 2nd of December, 1811, was named as the day for its completion. The bronze for the elephant was to have been obtained from the cannon captured by Napoleon in Spain ; but the further progress of the Peninsular contest, and other matters connected with Napoleon's eventful career, checked the progress of the enterprise : the foundation was laid, and a fine model in plaster of Paris was formed, but very little else was done. There was to have been a massive stone pedestal, on which the bronze elephant stood, and on his back a tower ; the whole on such a scale as to reach to the enormous height of eighty feet. A staircase leading up to the tower was to have been concealed in one of the legs of the figure, each of which was to have been upwards of six feet in thickness.

Paris contains a large number of fountains, supplied by nearly all the variety of means known in such cases. In the first place, when the capital of the Roman province of Gaul, Paris was supplied by an aqueduct five miles in length. In the middle ages this aqueduct was destroyed during a period of predatory warfare ; and it was not till the reign of Henri Quatre that arrangements were made for restoring it. For a very long period the erection and repairs were carried on at an enormous expense. A second aqueduct, constructed by Philip Augustus, was restored by Henri Quatre ; and besides these, there is the aqueduct of St. Germain, which brings the waters of Romainville and the neighbourhood into a reservoir, from whence it is conducted by leaden pipes to Paris. Another portion of the Paris supply is obtained by turning the course of a river so as to flow into the city. This river is the Ourcq ; and the project of making it available occupied a good deal of attention at various times, from 1799 till after the restoration of the Bourbons, when it was completed. The waters of the river were conveyed by a navigable canal into a large basin within the barriers, from whence the houses, manufactories, and fountains were supplied : the canal is twenty-five miles long, and answers the double purpose of traffic and a water-reservoir.

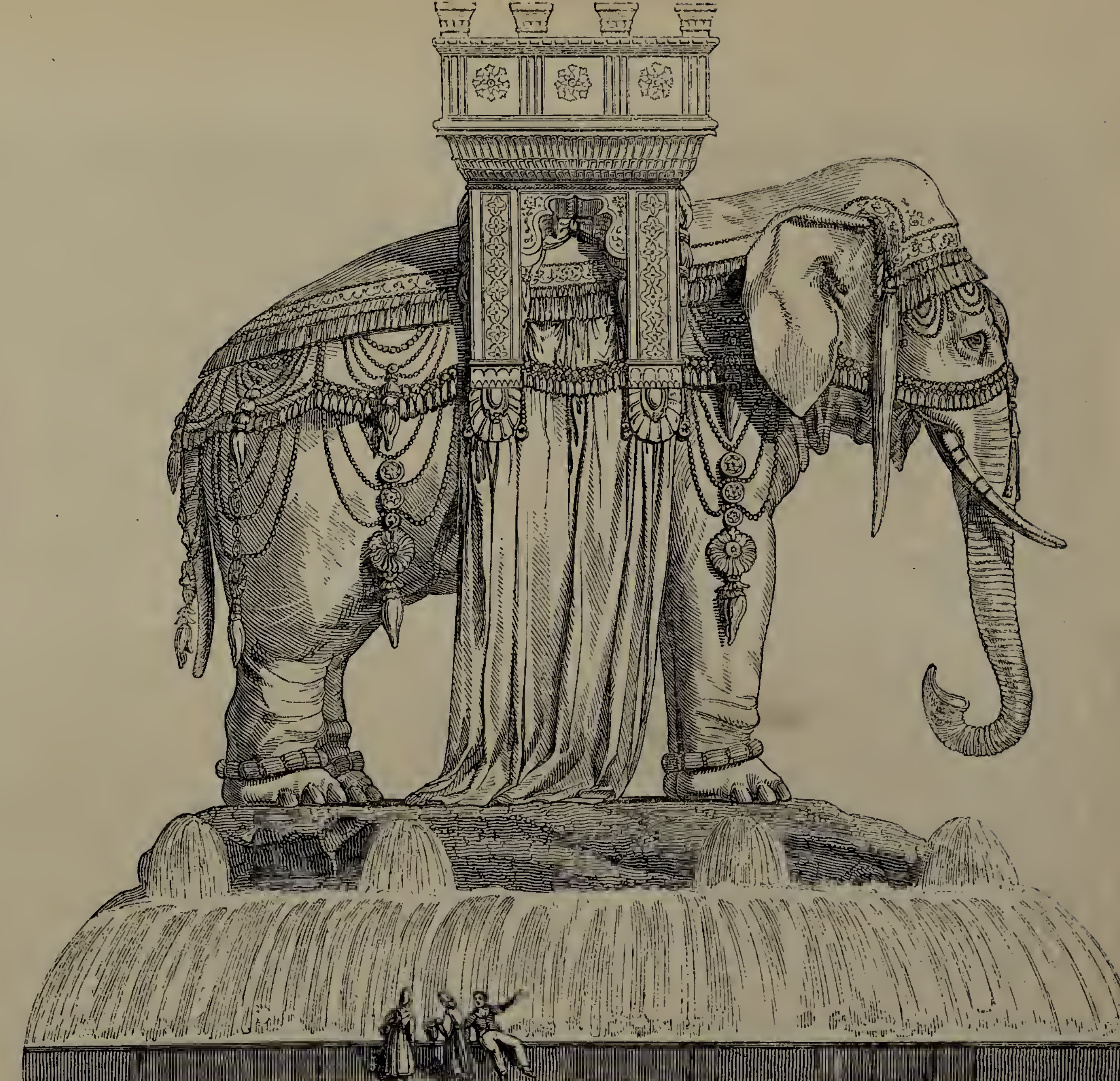
The aqueducts and river Ourcq form two of the sources ; while the fountains and hydraulic-machines for raising water from the Seine form a third kind. One of these machines was constructed near the Pont Neuf in 1608 ; another was constructed in 1671, near the Pont Notre Dame ; but both were so ill planned as to be of little service to the Parisians. About the time when the steam-engine was getting into note as a moving power, a proposal was made to raise water at Paris by such agency ; and a steam-worked hydraulic-machine was set to work on the Seine in 1782. There seems to have been a want of skill throughout ; for there was never an adequate supply ensured by these means. Besides these hydraulic-machines, there are about seventy fountains at Paris, and a hundred and thirty *bournes-fontaines*, or streams issuing from orifices in walls or posts ; so that if the water can be obtained at all, some care is taken to diffuse it among the different districts of the city.

Yet it must not be supposed that the difficulty here ceases. In London, almost every house except the poorest has a water cistern or cask, which is filled for the inmates at stated times without much trouble on their parts, and even almost without a thought. But in Paris this is by no means the case : attempts have been made to assimilate the practice at Paris with that of London, and the object will very likely be carried out by degrees ; but, as an illustration of general customs, the water-carrier system prevails at Paris, instead of the water-pipe system. Different ages, seasons, and countries may be illustrated by comparing the three cuts (Figs. 173, 174, 175), and considering the points to which they relate. The first of these represents one of the English conduits of the seventeenth century, and exhibits the customary mode of conveying water from the conduits to the houses, there being no other plan then in use calculated to supersede this. It is taken from part of a curious old sheet engraving in the British Museum, called ' Tittle-tattle, or the several branches of Gossipping.' While, on the one hand, it illustrates the usages of the time in respect to water-carrying, it is described (in 'London,' No. xiii.) as " apparently having for its object a little good-humoured satire against what the author appears to have thought the prevailing female vice of the age. Accordingly he has here represented groups of ladies at market—at the bakehouse—at the alehouse, where they are taking their ' noggins' of beer—at the hothouse, apparently a bathing-house, where in one compartment they appear to have just left or are about to enter the bath, and in another are refreshing themselves with some kind of collation—at the river, where some of the washers are beating the clothes with a small flat instrument like a mallet (the batter)—at the church, where the men and women are standing divided into separate bodies, the last all eagerly talking—and above all, at the *conduit*, where two of the ladies, being unable to agree as to the right of precedence, are endeavouring to settle the matter by a summary, but not very gentle or peaceful process ; in short, they fight, and with good old English earnestness."

Next, comparing this with Fig. 174, every one will call to mind the experience which winter gives us, and which shows that if any cause, such as severe frost, checks the flow of water to inhabited dwellings, the miniature conduit—the common " street-plug"—becomes the scene of the same water-carrying bustle as the " tittle-tattle conduit of past times. If, after this, we transport ourselves to the Place du Châtelet at Paris (Fig. 175), we shall find that both in winter and in summer an analogous system of itinerant water-carrying is observable. This fountain is called " La Fontaine du Palmier," or " La Colonne du Châtelet," and was erected in 1808 in the Place du Châtelet, where formerly stood a feudal court of justice and a prison. There are statues representing Justice, Strength, Prudence, and Vigilance, whose joined hands encircle the column ; the names of the principal of Napoleon's victories are inscribed on the column : and a gilt statue of Victory surmounts the whole. It is from such fountains as these that the water-carriers of Paris derive the supply which they retail to the inhabitants. These water-carriers, or " porteurs d'eau," are fifteen or sixteen hundred in number, in respect to those who carry the water in a kind of wheelbarrow ; while those who carry it as the London milk-dealers do their pails are still more numerous. The price paid is one *sous* for each pailful, and at this rate it was calculated a few years ago that nearly two hundred thousand pounds a year were paid to these men for water. " The water-carriers," it has been remarked, " are an industrious class of men, of simple habits, and very economical, for which they have an object sufficient to deter them from dissipation or ill-judged expenses. They indulge the hope of being some day enabled to possess a slip of land in their

168.—Leadenhall Conduit, 1655.

169.—Conduit in Westcheap.



171.—Design for the Fountain of the Elephant at Paris.

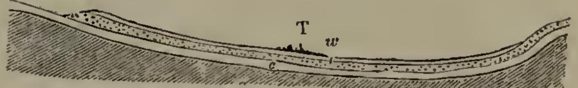
167.—Fountain of Paul V., Rome.

170.—Bayswater Conduit.

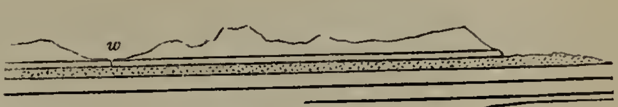
166.—Turkish Fountain.

175.—Fountain and Water-carriers in the Place du Châtelet.

174.—London Street-plug, in Winter.

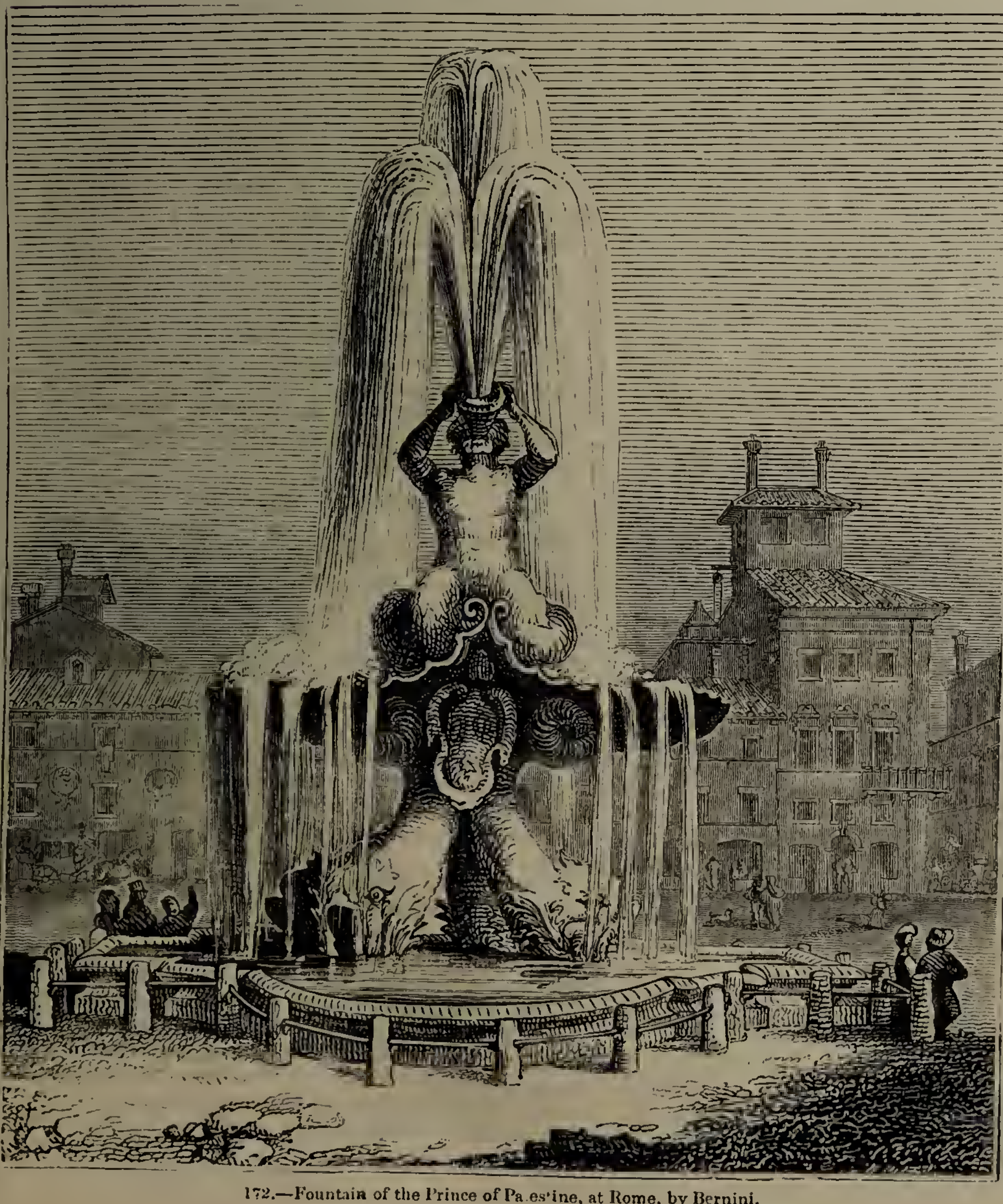


176.—Strata for Artesian Wells.

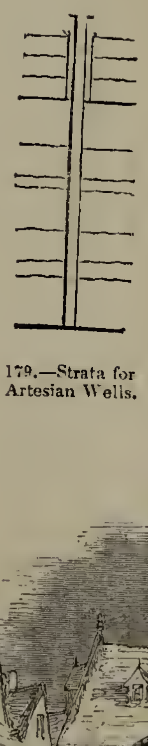


177.—Strata for Artesian Wells.

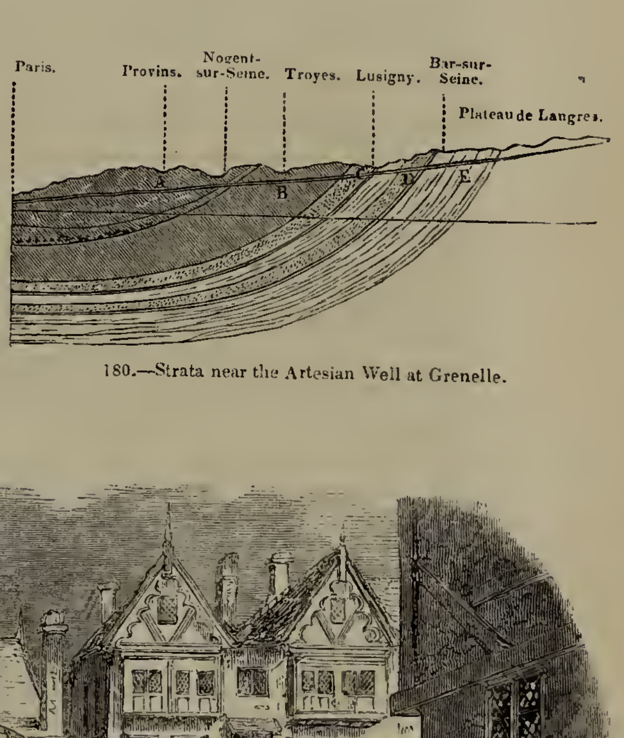
178.—Strata for Artesian Wells.



172.—Fountain of the Prince of Palestine, at Rome, by Bernini.



179.—Strata for Artesian Wells.



180.—Strata near the Artesian Well at Grenelle.

173.—London Conduit and Water-carriers: Seventeenth Century.

native department: the wife often assists in the labour of drawing the casks, which are placed on wheels; and is not less an advocate of every plan which can ensure the completion of their hopes."

Artesian Wells.

Modern science has devised a mode of procuring a supply of water, differing considerably from the greater part of those which have been engaging his attention. Instead of building structures on the surface of the ground, the *Artesian-well* arrangement depends principally on a deep penetration into the bowels of the earth, bringing up a hidden store of water to the light of day. The name "Artesian" is an ill-chosen one, for it does nothing towards explaining the peculiarities of the method to which it relates. A well so named differs, in a way which we shall presently explain, from a common well; but the name "Artesian" is derived from the province of Artois in France, where this kind of well is said (and even this point is disputed) to have been first adopted.

Let us consider a little what are the geological circumstances which give efficacy to wells, either of the Artesian or of any other kind. Whence does the water come which supplies a well? How is it that some wells must be dug so much deeper than others, and by what agency does the water rise vertically through so great a distance in deep wells? These are interesting points, worthy of a little study.

In the first place, it must be borne in mind that the strata of earth and stone beneath the surface of the ground differ very greatly in character. Some, such as clay, are so very close in texture, that water cannot flow between the particles; others, such as loose gravel, are almost as pervious as a sponge, allowing water to percolate readily between the grains of sand or gravel; while other varieties of soil are intermediate in quality between these two. Some, again, contain metallic and other matters soluble more or less in water; so that if water be flowing in contact with them, it will imbibe qualities not belonging to it in its native state. These different kinds of soil, too, are placed in a certain relation one to another; they are not intermixed confusedly, but are disposed in layers, sometimes lying horizontally one above another, sometimes in an inclined position, and in mountainous districts occasionally almost vertical. There may, for example, be a spongy or porous stratum, having a dense clay above it and chalk beneath it, and this relative position may be maintained although the whole of them together may be sometimes horizontal and sometimes inclined.

A porous stratum, then, thus hemmed in between others of a more impervious character, becomes the great reservoir to which well-makers have recourse; and we have next to see how this natural reservoir derives its supply of water. The evaporation which is constantly going on from the seas, lakes, and rivers of the earth, accumulates in the atmosphere a vast body of water, which has no means of escape except as rain, dew, hail, or snow. Rain, the most effective of these forms, descends from the clouds in quantity depending very much on the physical configuration of the country —in deluges at stated periods, in many of the tropical countries; in quantities so small as scarcely to be perceptible in Chili and a few other regions; and in moderate but (to us) uncertain showers, in England and similar countries. But whatever be the particular features at any one place, it is obvious that the quantity of water which thus falls to the ground must be immense. Now this water, when it descends to the ground, gives origin to all the rivers, great and small, which intersect the earth: falling on mountainous regions, it forms little rills and pools, which, collecting and combining their waters, and gathering strength and body as they proceed, form at length a small river, which—seeking the lowest level, in accordance with the laws of fluid pressure—flows gradually down the inclined surface of a country towards the sea; making for itself a path around and among hilly or rocky obstructions, and swelling at length till it pours into the ocean such mighty streams as the Ganges, the Nile, and the Mississippi.

But a portion of the water which thus falls takes a somewhat different route. If a porous stratum of earth bends upwards into a mountain district, and there "crops out," as geologists term it, or appears at the surface, the rain which falls on this exposed portion, instead of flowing over the surface, as it would over a more impervious stratum, becomes absorbed into the porous soil, and slowly follows the course of the spongy stratum wherever it goes, whether horizontally or descending obliquely. If, as often occurs, the porous stratum follows the contour of a hill, and also lies beneath the surface in a neighbouring valley, the water percolates slowly downward until it arrives beneath the valley. But (it may now be asked) if the water lies deposited beneath the surface of a valley, why does it not rise to the surface and overflow a country? It *would* rise if there were a porous medium to bring it to the surface; but there is a thick bed, either of clay or of some other impervious material, intervening between it and the surface; and it is for the express purpose of piercing through this intervening bed that wells are dug or bored.

These points may be illustrated by two or three figures. Suppose Fig. 176 to be a section of the undulating surface of a country, with a town, T, situated in the depressed or valley part, the higher portions at the ends representing hilly districts at some distance. Immediately beneath the surface is a stratum (left white) supposed to be impervious to water; next below this is a porous stratum through which water could find its way; and beneath this another impervious stratum, *c* (white). Now all these strata follow the general curvature of the valley, in such a way that the porous stratum comes to the surface at the hilly districts. The rain which falls on this exposed portion cannot escape upwards or downwards from it, because it is bounded above and below by impervious strata; and it therefore follows the course of the spongy soil till it comes beneath the town at T. Here a well, *w*, being excavated through the uppermost of the impervious strata, allows the imprisoned water an outlet to escape; and the water rises because the town is on a lower level than the spot at which the rain entered the porous stratum. Again, in Fig. 177 the various strata, instead of forming a basin or hollow, have a general slope in one direction; yet if a well be dug at any point (*w*) lower than that at which the porous stratum is exposed at the surface, water will rise in the same way as before. Sometimes there is, as in Fig. 178, a disruption of strata, whereby, at a spot called by geologists a "fault" *(f)*, the pervious stratum is suddenly lowered out of its regular direction; and at such a point the water frequently rises to the surface as a natural spring. Still, if a well be dug at *w*, higher up than the fault, but lower than the exposed portion of the spongy stratum, water will rise in it.

It depends very much on the thickness of the various strata whether the well must be deep before it reaches the watery bed. Sometimes a few feet will suffice; sometimes hundreds are necessary; and according to the elevation of the source whence the water is derived. It has been recorded that in a garden at Isleworth a well was bored through twenty-four feet of mould and gravel, and about three hundred and thirty of stiff clay; after which the water rushed up through the aperture (nearly equal to the height of St. Paul's), and made a fountain ten feet from the ground. In another well, near the same spot, a bore of nearly three hundred feet brought up a gush of water to a height of thirty feet above the ground. A well has been sunk at Wimbledon five hundred feet without finding water. At Deptford, in a well more than two hundred feet deep, the water rose to within ten feet of the surface; while in other cases the water, though reached by the perforation, rarely rose to within sixty feet of the surface. Mr. Mylne, the engineer to the New River Company, has collected some curious examples of the way in which one well will influence another, showing that the watery strata extend for a great distance under London. A well at Coutts's banking-house, formerly dried up, afterwards yielded so plentifully that the water flowed over the top of the well, and thence found its way to the Thames; but other wells having been sunk in the neighbourhood, the flow in this one has been sensibly lowered. Barclay's brewery is situated nearly opposite Calvert's, the Thames flowing between them; and it has been stated that when the pump in the former is worked, the latter is sensibly affected, thus showing the connexion of the watery strata even beneath the bed of the river. At others of the great London breweries similar results have been observed; one well robbing another, and the latter retaliating when dug deeper into another watery stratum.

A well, of the common kind, is simply a pit dug with pickaxe and shovel, and lined with brickwork to prevent the loose earth from falling in. But an Artesian well is merely a small tube, much too small to be dug by men, and yet large enough to allow water to flow upward in large quantity. It is produced by using boring-instruments affixed to long handles or rods. The depth to which they are bored depends not only on the depth of the watery stratum, but on the quality of the water reached. It often happens that there are two or more porous strata one above another, with impervious strata between them, and that the uppermost of these gives to the contained water an impure character, by reason of sulphur, or lime, or some other substance contained in it. Then the well is bored deep enough to reach the lower stratum; and an enclosed cylinder keeps back the water of the upper one. Thus Fig. 179 may represent a number of strata one above another, with an Artesian well (*h*, *l*) perforating them all vertically: supposing the well to reach a stratum of good water at the bottom, and to pass through strata of impure water near the top; by enclosing the upper part of the tube or well with an additional cylinder (*h*, *k*) the bad water is prevented from rising or mixing with the good.

The formation of the Artesian well at Grenelle in France will illustrate very instructively this mode of raising water. Grenelle is a suburb of Paris, and being very poorly supplied with water, it was proposed to bore an Artesian well. But the nature of the strata beneath Paris and the surrounding districts rendered it certain that any well made there must be very deep. Fig. 180 will give an idea (of course exaggerated) of these strata. The sloping line is the general inclination of the country towards Paris; while the horizontal line is the level of the sea, and the curved lines represent several successive strata, A, B, C, D, E, such as clay, chalk, sand, and limestone; and it was necessary to sink the perforation till it arrived at a watery stratum deriving its waters from the surface at some distance from Paris. It was well known that this would be at a great depth; but experience had to show how far the attempt was practicable. M. Mulot, an engineer, commenced operations about the year 1833, in the following manner:—

The necessary works were commenced by means of boring-rods about nine yards long, attached to each other, and which could be raised or lowered by mechanical means; an ingenious method being adopted for giving them a circular motion. The diameter of the bore-hole was about six inches. The instrument attached to the end of the lowest boring-rod was changed according to the different strata successively reached; the form adapted for passing through the softer materials being unsuitable to boring through the chalk and flint, a hollow tube being used for the former, while the latter was penetrated by a chisel-shaped instrument. The size of the rod diminished in proportion to the depth. During the progress of the works many accidents occurred, which tried the patience of the engineer to the utmost. In May, 1837, when the boring had extended to a depth of four hundred and eighteen yards, the hollow tube, with nearly ninety yards of the boring-rods attached, broke, and fell to the bottom of the hole. It was necessary to extract the broken parts before any further progress could be made; and the difficulty of accomplishing this may be conceived from the fact that it took fifteen months to withdraw the different fragments! Again, in April, 1840, in passing through the chalk, the chisel became detached from the boring-rod, and before it could be recovered several months were spent in excavating round it. At length, in February, 1841, after eight years' labour, the rods suddenly descended several yards, and entered the watery stratum which had so long been sought, at the enormous depth of eighteen hundred feet! The water rose up the excavated hole in the course of a few hours, and discharged itself at the top at the rate of six hundred thousand gallons per hour. A pipe was carried up, by means of scaffolding (Fig. 181), nearly to the top of the jet; and various arrangements were afterwards made to render the supply practically available for the inhabitants in the neighbourhood.

Artesian wells are now employed very extensively in different countries. As it is an ascertained fact that the temperature of the earth increases at an increased depth, it has been supposed by some geologists that *warm* water may be obtained by means of Artesian wells of enormous depth; and projects have even been entered into to test the practicability of the idea. For instance, a year or two ago M. Arago announced the intention of the French government to make an Artesian well in the Jardin des Plantes, of a depth of 900 mètres (considerably more than half a mile), 200 mètres deeper than that of Grenelle. The water thence obtained would, it was supposed, be of a temperature of 31° Centigrade (equivalent to 88° Fahr.); and will, if the anticipations be realized, be employed to heat the hothouses of the gardens, and supply the hospitals of La Pitié and La Salpetrière, and thus effect a great economy as to fuel. Should this be effected, it will be a wonderful mode of borrowing from Nature one of her hidden agents, and making it applicable to the every-day purposes of man.

Modern Water-works.

The wells, the aqueducts, the fountains, the conduits, the Artesian wells—although comprising pretty nearly all the available means for procuring and conveying water—do not quite include all. There are the "Water-works," or hydraulic arrangements for raising water from a river, to a reservoir at a height sufficient to accommodate all the houses of a town.

Many readers will remember the time when there were such Water-works at the foot of old London Bridge, comprising rather a complicated system of wheels and mechanical arrangements (Fig. 182). It was in 1582 that one Peter Morris, a Dutchman, constructed the Water-works at London Bridge for supplying the citizens. The Works were originally moved only by the tide flowing through the first arch; but a much larger portion of the river's width was afterwards taken in, to the no small inconvenience of the navigation. The lease under which the Works were granted at last comprehended all the stream of the river, to the fifth arch inclusive; and the Works, becoming by degrees very powerful and complicated, continued in operation till an Act of Parliament was obtained for their removal in 1822. It has been well observed that—"The imagination is impressed by the mere stability of a dead structure which long outlasts the

ordinary date of the work of human hands, and has stood unmoved amid the changes of many generations, remaining among us an actual portion of that old time and scene of things, all the rest of which has passed away; but we are interested, perhaps still more vividly, by anything in the contrivances of man, like movement and action sustained without interruption, through the lapse of centuries—for this is, as it were, a portion of the very life of the past retained by us. The creaking and jingling of these London Water-works, therefore, after it had been going on for two hundred and forty years, must have been curious to listen to; and the last time the wheels went round was a solemn and touching thing, a sort of death, and that too of an existence that had done the world some service, as well as been protracted to no ordinary span."—*London*, No. 5.

In such Water-works as those here alluded to the water has a twofold character. In the first place, there is a wheel, or a system of wheels, so placed in the river that the ebb and flow may act upon float-boards, and force the wheel to revolve; while, in the second place, the rotatory force so produced is made to work pumps by which water is drawn up from the river into an elevated reservoir. There is a splendid system of Water-works thus arranged in the river Skuylkill in Pennsylvania, and others in other parts of America. Different countries of Europe, too, exhibit specimens, more or less important, of the same character.

In past times, when it was the custom in France to speak in rhapsodical adulation of everything done by the "Grand Monarque," Louis XIV., there was an hydraulic machine, called the "Machine de Marly," which was made the theme of high praise. The machine was erected upon the Seine about twelve miles from Paris, and occupied the entire width of the river. The breadth of the river was divided into fourteen watercourses, in each of which was placed a large water-wheel. The stream turned these wheels; and by the motion thus produced, sixty-four forcing-pumps were worked. The water raised by these pumps passed through large iron pipes to a height of a hundred and sixty feet, and was deposited in a reservoir excavated in the side of a hill. From thence eighty more forcing-pumps propelled it through pipes to a greater height; and then eighty more drove it yet higher. So extremely clumsy and unscientific was the mode in which these pumps were set to work, that it has been computed nineteen-twentieths of the entire power applied was expended in moving the rods and chains of the pumps themselves, and only one-twentieth in really raising the water! The water rose to the summit of a tower on the brow of a hill; and from thence it flowed along an aqueduct of thirty-six arches to the place of its destination. The first cost of this machine was three hundred thousand pounds sterling, and the expense of keeping it up was about three thousand a-year. In 1738 some improvements were made, whereby the loss of power was in some degree obviated; in 1775 another improvement was effected; and in the time of Napoleon a sum of a hundred thousand pounds was spent in substituting steam-power for raising the water up the hill.

Sometimes a river is brought from a distance by an artificial channel, and then distributed through a town by machines and pipes of various kinds. Such is the case with the noble work of Sir Hugh Myddelton, the "New River." In Elizabeth's time a plan was suggested for diverting to London some one of the smaller streams flowing in Middlesex or Hertfordshire; but it was not till the next following reign that Hugh Myddelton, "citizen and goldsmith," took the matter up in earnest. An agreement being concluded, Myddelton fixed upon two springs rising in Hertfordshire, at Chadwell and Amwell. The distance from these springs to Pentonville is about nineteen miles; but, what with difficulties of ground and difficulties with landowners, Myddelton had to make his artificial channel or viaduct nearly forty miles long. Bridges, drains, sewers, arches—all had to be made; and Myddelton had to surmount the difficulty of making them, without having at hand so many resources as the modern engineer. He spent all his own fortune, and the corporation of London refused to assist him; but the king advanced funds, offering to supply half the entire expense on condition of receiving half the profits. The agreement was made; the works were completed; and in 1613 the water poured into the reservoir at Pentonville. But Myddelton had only a heart-aching return for his noble scheme. For eighteen years it paid no dividend whatever, and then only a small one. Later ages, as in many other instances, have profited immensely by that which brought little save honour to the benefactor.

A similar transference of water, more or less extensive in scale, is effected in other cities. Thus Greenock is supplied with water by a channel some miles in length, bringing the waters from several streams in a neighbouring range of hills. Edinburgh is supplied in a similar way from hills southward of the city; and there is at the present moment a project under contemplation for bringing water along the line of the proposed Caledonian Railway. In America there has recently been constructed a vast system—the Croton Aqueduct—whereby the contents of a river are brought forty miles to New York, along a stone viaduct which crosses valleys and rivers, and pierces hills, till it terminates in a vast reservoir from which the inhabitants are supplied.

We must not forget that, whether the water is obtained in the first instance from one or the other of the various modes which have been noticed, the distribution from house to house is a modern improvement, carried on more completely in London perhaps than anywhere else. There is, in the first instance, a large reservoir, such as those at Pentonville, or in the Hampstead-road, near Primrose-hill, and elsewhere; and pipes of large bore convey the water from these reservoirs through the principal streets. The reservoir is always on an elevated spot, so as to give a descent from thence to the houses; and sometimes there is a syphon or bent-tube placed in the reservoir, which, when kept full of water, enables the water (by its tendency to seek a uniform level) to reach the upper rooms of all the houses in the district. Some of the greater pipes are three feet in diameter: they are made in short pieces, and are joined end to end by means of an overlapping joint, one variety of which is sketched in Fig. 183. Some of these pipes, in conforming to the variable level of the ground, become incommoded with air which gains entrance; and in a case of this kind some sort of air-valve, such as Fig. 184, is occasionally employed. From the largest pipes, passing only through the main streets, branch off others of lesser diameter, for the second-rate streets; and from these smaller ones again; every pipe being connected with the houses by means of smaller pipes made of lead.

As to the internal arrangements of houses in these matters, some are very curious, and illustrate the endeavours made to save trouble. When the water flows into the leaden pipes with which the houses are supplied—whether it comes from the New River, or from the reservoirs filled from the Thames—it generally enters a cistern, or a butt, which will contain only a definite quantity; and as it continues flowing for a much longer time than is necessary to fill an average cistern, it is necessary to have some means of stopping the flow. This is effected by a cock, or valve, applied at the end of the supply-pipe. But even this is not enough. The time necessary to adjust this valve is now spared, and it adjusts itself by means of a floating copper ball. The forms which this kind of apparatus has assumed have been very various. Fig. 185 will give an idea of one of them. A hollow copper ball is connected by a lever with a valve, which closes the lower end of the supply-pipe: when the cistern or vessel is becoming nearly filled, the ball, being light from its hollowness, floats on the surface of the water; and the stem to which it is attached, rising at the same time, closes the valve, and prevents any more water from flowing. Another proposed arrangement is seen in Fig. 186, where a cork or float is attached to the lower end of the rod which bears the valve; so that as the valve rises by the ascent of the cork it closes the pipe, and allows no more water to flow out. Fig. 187 is another arrangement, showing part of the lever, in two positions, and the valve which closes the pipe.

All the multiplied little arrangements connected with the distribution of water through a house may be passed over as being too familiar to require note; but it may not be altogether out of place to describe the chief points involved in the use of *pumps*.

Every one knows that a pump is connected with a well in which the water remains at a level some distance below the surface of the ground; but how it happens that the handle of the pump becomes the means of drawing forth this supply is not perhaps so well known. Fig. 188 will give us an idea of the general arrangement of two or three kinds of pump, and, at the same time, will afford the means of showing how they act. The left side of the figure shows a *forcing-pump*, used to raise water to a small height, or from a small depth. A vertical rod is connected with frame-work, to the lower part of which a piston P is attached by its rod *e*. This piston works air-tight through a barrel or cylinder B. On alternately depressing and elevating the rod, the water is drawn up into the barrel, and finally expelled from the pump. In the right-hand figure the valves and barrel are so arranged, that the water from B is not only raised, but is forced upwards to a great height. In the middle figure the arrangement is that of a *suction-pump*, in which the piston does not descend so low as the water. The first action of the pump is to draw out the air from the smaller or lower part of the barrel; and a vacuum, or partial vacuum, being thus created, the water rushes up into it by the pressure from without, and comes within reach of the piston, which then raises it to the surface. All pumps act on one or other of these principles, or on both of them combined, modified according to circumstances; the piston either raising and forcing out the water, or else making a vacuum, into which the water rushes. Many variations of arrangement occur, of which Fig. 189 is one example.

This rapid sketch, then, will have shown that a large amount of inventive ingenuity and art have been developed in the attempt to make available to us the bounteous supplies of water which are at our disposal. The arrangements for bringing water actually into the houses of the consumers are more important in every way than we are in the habit of thinking; for the cleanliness and health of the people are measured a good deal by the trouble required in procuring water. Mr. Chadwick, in his 'Sanatory Report,' quotes from the Rev. Whitwell Elwin, the chaplain of the Bath Union, the following illustration of the habits of many of the working population, even in that city, which is well supplied with water:—"A man had to fetch water from one of the public pumps, in Bath, the distance from his house being about a quarter of a mile;—'It is as valuable,' he said, 'as strong beer. We can't use it for cooking, or anything of that sort, but only for drinking and tea.' 'Then where do you get water for cooking and washing?' 'Why, from the river; but it is muddy, and often stinks bad, because all the filth is carried there.' 'Do you then prefer to cook your victuals in water which is muddy and stinks, to walking a quarter of a mile to fetch it from the pump?' 'We can't help ourselves, you know; we could not go all that way for it.' There are many gentlemen's houses in the same district in which the water is not fit for cooking; and I know that much privation and inconvenience are undergone to avoid the expense of water-carriage. I have often wondered to see the shifts which have been endured rather than be at the cost of an extra pail of water, of which the price was three-halfpence."

FUEL AND ARTIFICIAL WARMTH.

If to one source—the evaporated and subsequently condensed waters of seas and rivers—we owe one of the priceless comforts of life; so do we owe another to the lifeless remains of vegetable growth. When we know that coal is found at varying depths beneath the surface of the earth; that peat is a spongy mass on the surface; that street gas is procurable from coal; and when we compare these with the wood of a tree, felled and brought into usable form—we may have a tendency to think that the materials from which we derive fire and artificial warmth are really of very diverse origin. But the more the matter is investigated the more reason does there appear to entertain the opinion that all in common derive their origin from plants. The tree, when living, ministers to our wants in forms absolutely numberless; the tree, when dead, gives cheerfulness to the otherwise cold hearth, and enables us to bring into use the crude materials lying around us. It may be well to speak of "dead" trees, because the term conveys a familiar idea to the mind; but it is also well to bear in thought that this death is, in the operations of nature, only the beginning of a new course of usefulness. The tree received from the earth the sustenance necessary to its growth; it gives back in return an agent which will melt and separate, and purify, and render available to man, the mineral wealth which now lies hard and cold beneath us.

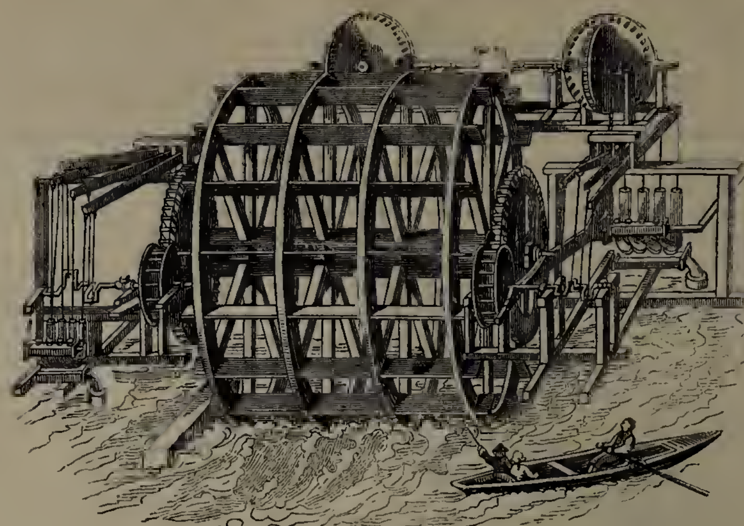
That coal and peat are derived from the woody portion of plants, is an opinion established only in modern times; and even yet there are many who hold the theory as not wholly free from doubt. Those, therefore, who in past ages have used these materials as fuel, did not regard them as we now do: they accepted the welcome gift, but knew not how it was formed. A very much larger portion of the earth's inhabitants at all times, however, have remained ignorant of the use of these varieties of fuel, and have contented themselves with the use of wood simply as such, when cut from the felled tree.

In a work recently published on this subject by Mr. Bernan, the following judicious remark is made:—"These examples will be sufficient to show the need of artificial heat for personal comfort under the most opposite conditions of climate, as well as the sacrifices of enjoyment and health that are everywhere made to obtain it. When, therefore, the Laplanders and other inhabitants of Arctic regions are observed passing three-fourths of their time in hot, contaminated, factitious atmospheres, and Swedes, Poles, Russians, and the natives of more southerly climates, spending half their lives in closed rooms kept at the temperature of summer, it is clear that *artificial heat* must have a great effect in producing the general result that is usually ascribed solely to the operation of natural climate. Accordingly it is found, that as firing is scarce or abounds in a particular territory, or as it is cheap or high-priced, and more or less skilfully managed, the natives exhibit mental and bodily peculiarities as if they were inhabitants of opposite geographical climates."

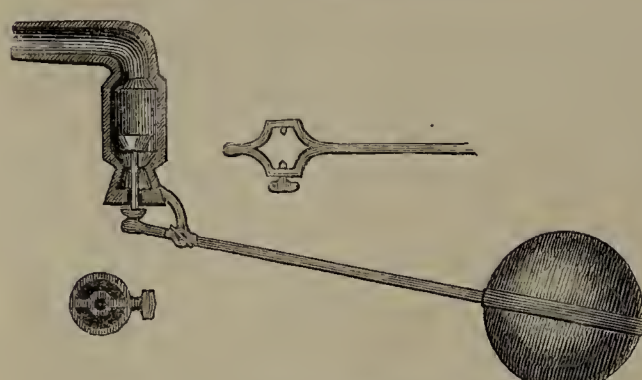
Wood-Fuel.

Throughout the East, wherever a woody district occurs, the use of this kind of fuel is very prevalent. Sometimes dried refuse of various kinds is made up into cakes or pieces, and used to produce a smouldering fire; but wood is the grand resort. The tales respecting "wood cutters," from Ali Baba downward, are familiar to all readers, and point to the existence of a class of persons (Figs. 191, 192) whose employment

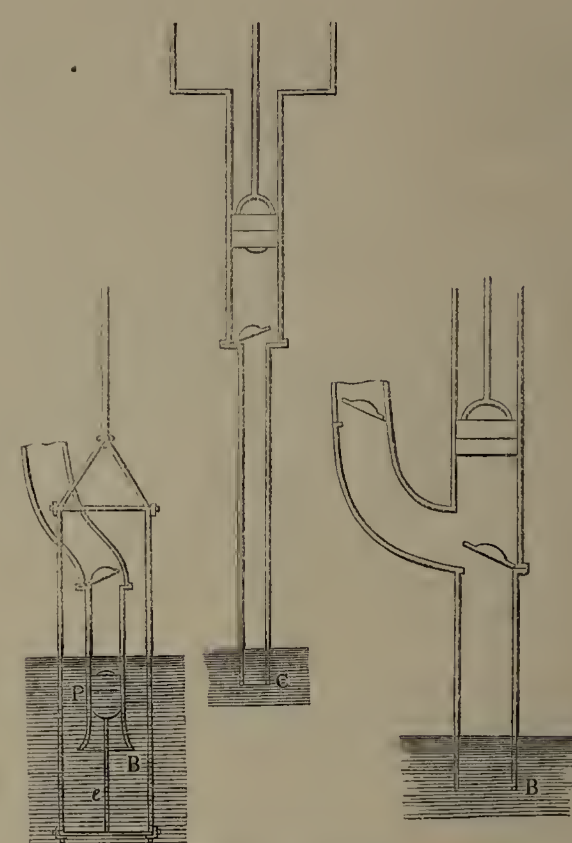
181.—Artesian Well at Grenelle, near Paris.



182.—The old Water-works at London Bridge.

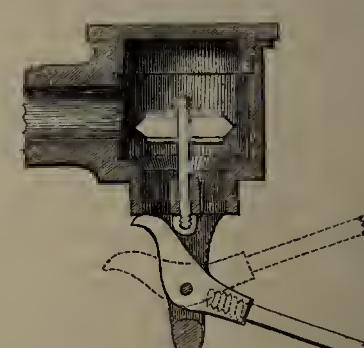


185.—Water-pipe Apparatus.



188.—Forcing and Lifting Pumps.

189.—Pump.

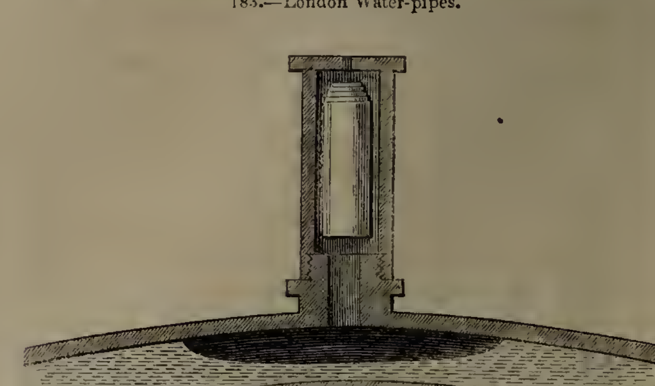


187.—Water-pipe Apparatus.

186.—Water-pipe Apparatus.

183.—London Water-pipes.

190.—Wood Cutters and Carriers in the Forest of Brotonne, Normandy.



184.—London Water-pipes.

193.—Wood-Yard and Raft on the Seine, Faubourg St. Antoine, Paris.

192.—Fire-wood Carriers in the East.

195.—Coke-Ovens.

191.—Oriental Wood-Cutters and Carriers.

194.—Peat-Gatherer in Ireland.

depended principally on the use of wood for fuel. It is now a tolerably well-established fact, that coal is a more economical material for fuel than any other, in a populous country; and that it is more advantageous to appropriate the land to other purposes than that of producing fire-wood. But it is not till a nation becomes far advanced in the usages of civilized life that this matter is understood; and in many cases where there is no disinclination to believe the fact, the non-existence of coal in the country debars the inhabitants from making a choice as to fuel.

France, although so prominent among the nations of Europe, is yet obliged to depend very largely on the produce of her forests for fuel. Hence the wood-cutters and dealers are there an active race. In many parts of the country little troops may be met with, consisting of horses with loads of wood fastened on their backs in a peculiar manner, accompanied by men, women, and boys, as in Fig. 190. Of such a scene as this an eye-witness has observed:—"The poor wood-cutter, his wife, and boy, are going probably to some neighbouring village or town, to sell to the retail venders the faggots piled up upon that very curious and ingeniously-shaped saddle, into which the horse's back fits so exactly; and with the money thus obtained they will purchase the necessaries required for their humble household, and which are to last them until the next journey. The persons engaged in this most primitive of occupations, are a quiet, simple-hearted people, very ignorant, but, at the same time, very contented; their chief wants—food and clothes—are generally well supplied, and their chief desire, amusement, seldom lacks opportunities for its gratification. They are very superstitious, and on the festivity of Corpus Christi will walk miles to touch a headless statue of St. Louis, or to count a rosary at the foot of an equally mutilated semblance, whether in stone or in wax-work, of their celebrated St. Mein. The females of this class, like most others in Normandy, are fond of bright showy colours in their apparel, particularly red, which they use in every variety of tint. The petticoat is perhaps of intense red, the neckerchief pink, the apron striped with orange; and not unfrequently "bend over all," not exactly the "blue sky," but the much less poetical canopy of an immensely large scarlet umbrella, which is used as a defence for the overpowering heat of the sun. Seen among the depths of the green forests, such forms give a richness and harmony to the picture which would otherwise be wanting."

Although there are coal-mines in forty different departments of France, yet the abundance of fire-wood produced in the forests is still sufficiently great to prevent coal from being used exclusively, even where the wood is not procurable; while the want of internal means of communication still further limits the use of coal. Many of the French collieries are actually lying idle, or nearly so, because the expense of the coals themselves, added to the cost of transport over insufficient roads and canals, raises the price too largely to enable the seller to compete with the forest proprietor. It has been stated that in the department of Aveyron the coal-mines, if properly worked, would provide a supply nearly equal to the wants of France; but that the deficiencies in respect to roads and canals render this bounty of nature almost unavailable. One-eighth part of the surface of France is still covered with woods and forests, the annual produce from which, comprising building-timber and fire-wood, is estimated at five or six millions sterling. Ten years ago it was estimated that France, with one-half as many more inhabitants, consumed only one-fifth the quantity of coal consumed in England. The consumption of every kind of fuel in Paris amounted at that time in value to nearly seventeen hundred thousand pounds sterling annually, being nearly one-half the amount of the annual rental for all the houses in Paris, and two-thirds of the sum spent by them in wearing apparel! This estimate, if correct, places in a striking point of view the expensive nature of wood-fuel. Eighteen years ago the total consumption at Paris was computed at a million *stères* of fire-wood, four million faggots, two million *hectolitres* of charcoal, and one million *hectolitres* of coal. It may not be superfluous to English readers to state that a *stère* is a cubic *mètre*, or a bulk containing about thirty-five cubic feet English; and that a *hectolitre* is equal to about twenty imperial gallons, or two bushels and a half.

The fire-wood for the supply of Paris (which pays duty on entering the city) is brought down the river Seine in rafts. Sometimes the supply is obtained from a great distance, and in that case the wood is seasoned before being made up into rafts: the bark is stripped off at the time of the wood being cut, and then allowed to remain exposed, the wood becomes hardened, and much better fitted to be used as fuel. Some forests, contiguous to the Seine, are preferred to others in respect to the quality of the wood thence obtained: one kind, for instance, obtained from trees growing in a stratum of stones and gravel, is much esteemed at Paris. Two or three other kinds are used on account of the pleasant perfume which they emit; while others also are in good favour for the bright, sparkling, and cheerful blaze which they yield. The attraction thus procured is however paid for at a very dear rate; and to economize fuel the Parisians often keep their fires in a smouldering state, or use a kind of charcoal-composition with the wood.

When the wood-rafts arrive at Paris, which they do to the number of four or five thousand every year, they stop at the Ile Louvier, one of the three islands formed by the Seine within the walls of Paris. Here wood-depôts are established, such as that sketched in Fig. 193, from whence the retail-dealers in this commodity obtain their supply.

In France and Germany the selection of the best wood for fuel, and the cultivation and protection of the trees yielding it, have been made the subject of a separate branch of practical education. The best wood for fuel is oak: the next is beech; and the harder the wood, in a general way, the more heat it gives out in burning. The trunks of large trees, sawn into convenient lengths, and then split into billets, make the best fuel; but where wood is scarce, it is found most profitable to cut down the trees when from thirty to forty years old, when they have acquired a considerable height of stem, but no great girth. In the woods which are planted for this purpose in France and Germany the trees are made to grow slender, by being placed near together, and most of the lower branches being cut off. This is a well-known mode of determining the manner in which a tree or plant shall grow, whether tall and spare, or short and bulky; and it is simply a matter of calculation, under any particular circumstances, as to which of the two methods will be, on the whole, most conducive to the object in view.

About sixty or seventy years ago there was a German traveller, Riesbeck, who gave rather a quaint account of the condition of Prussia at that time; and while defending certain monopolies which existed at that time, and which he said were established by the king for the good of his people at large, he gives us an insight into the employment of wood for fuel, the sale of which was monopolized by a company:—"This company is not allowed to set an arbitrary price on its commodity, but the wood is taxed; and they are obliged to furnish the best sort. Though the price of the wood be high, it keeps pace with the wages of the manufacturers; so no one man feels it but those who live upon their own estates without doing anything, or those who receive stipends from the court. If the former of these would work like the other parts of the industrious public, they would reckon the article of fire-wood in their account; as they do not, they are very properly punished for their laziness. As to the latter, to be sure they do not get much, but what they get is sufficient for the decent purposes of life; and the king's maxim is, that every man shall have enough, but no man shall have too much. To the farmer the monopoly is of service, for the company is obliged to sell him the wood as cheap as if there was no monopoly; and, besides, he is himself allowed to take a certain portion of it to market, where the regulations enable him to sell it to better advantage than he would do otherwise. The monopoly also serves to preserve the forests, which all Europe has long lamented the diminution of. The scarcity of wood makes people more cautious how they grub up and burn. Nor does the monopoly affect any but the inhabitants of Berlin and Potsdam, who have great advantages over the rest of the country, from the residence of many officers of state in them, and the facility with which money circulates. Strangers, indeed, who reason from the state of their own purses, and see that the materials for fire are as dear at Berlin and Potsdam as Brazil and Campeachy wood, form no prejudices in favour of the Prussian monopolies, and thus far they are in the right." The last fact mentioned, relating to the price of fire-wood being equal to that of dye-wood and ornamental wood brought from abroad, is not a little remarkable.

Peat-Fuel.

Respecting the employment of peat for these purposes, Mr. Holland, in his interesting 'History of Fossil Fuel,' remarks:—"The most common article of domestic firing in the less wooded districts of this country, previous to the general use of pit-coal, was turf or peat, a species of fuel still dug and burnt in large quantities in places where it abounds, and where wood or coal is scarce or unattainable. It would be difficult to say at what period the material now under consideration was first applied to its long-acknowledged useful purpose: that it was used, as it is at present, from a very early period of our history, there can be no doubt; and in the absence of ligneous and mineral fuels especially, its great abundance, easy obtainment, and singular production, arrest attention to one of those sources of comfort and convenience, which an infinitely wise providence has opened in the store-house of Nature for the benefit of mankind."

There is nothing in the appearance of this substance which would lead to the opinion that it is fitted to serve as fuel; and there seems some ground for the opinion that spontaneous ignition of turf may have led to its general use. That such spontaneous effects are sometimes produced is well known. Thus, in 1833, the heat of the ground in Switzerland was so great as to inflame it spontaneously; in the following year a moor took fire in Livonia; and in the middle of the last century the inhabitants of a Siberian village, having removed to another spot to avoid a marshy situation, accidentally kindled the ground near the village, and it is said to have burned for half a year. Now in cases of this kind, although we say in common parlance that the *ground* took fire, it is easy to see that mere earth could not so burn, and that there must have been something of a more inflammable nature, partaking more or less of the bituminous character of peat.

When it became well known that peat, or bog-earth, or turf, or moss (for these names are all applied in rather a vague manner) was inflammable, numberless opinions were broached to account for its formation. Some thought it was formed at the same time as the valleys in which it is found: some regard it as a bituminous deposit from the sea: some as the wreck of islands which once floated: some deemed it to be of mineral origin. Dr. King, in a paper presented to the Dublin Society many years ago, said—"Ireland doth abound in moss more than, I believe, any kingdom, insomuch that it is very troublesome, being apt to spoil fruit-trees and quicksets. This moss is of divers kinds: that which grows in bogs is remarkable; your light spongy ground is nothing but a congeries of the threads of this moss, before it is sufficiently rotten (and then the turf looks white, and is light). I have seen it in such quantities, and so tough, that the turf-spades would not cut it: in the north of Ireland they, by way of joke, call it *old wife's tow*, and curse her that buried it when it hinders them in cutting the turf: it is not much unlike flax: the turf-holes in time grow up with it again, and all the little gutters in bogs are generally filled with it."

The peat-bogs of Ireland, and the employment of this material for fuel by the poorer classes of the inhabitants, are among the most characteristic features of that country. The bogs extend over a very large surface, and present a most monotonous and comfortless appearance. One of these, the Bog of Allen, stretches over a considerable breadth of country westward of Dublin; and there are two towns, Philipstown and Tullamore, situated on it. There is a somewhat waggish address to this bog, known in Ireland, running thus:—

"Great Bog of Allen, swallow down
That odious heap called Philipstown;
And, if thy maw can swallow more,
Pray take—and welcome—Tullamore."

From this bog, and from others of similar character, the poor peasantry gather the turf which is to serve them for fuel, and which perchance they may sell to their neighbours as a merchantable commodity. Many a district in Ireland could exhibit a sketch such as Fig. 194, where the peat-gatherer, with a basket at her back, is wending her way to or from the spots where the fuel is to be procured. In Mr. and Mrs. Hall's 'Ireland' is a concise account of the proceedings of the peat-gatherers, from which we may glean a few particulars. When the peat-gatherers are removed a little above absolute poverty, they often club together, and manage their trade somewhat on a commercial system. In the first place, the turf is cut by means of a turf-spade: this spade is narrower than a common spade, and has a ledge at right angles to one side. One man having cut the turf in slices by means of this spade, another throws the turf into barrows, and wheels it away; a third man goes before the turf-cutter, levelling and preparing the ground; while a fourth assists in loading the barrows. The four who thus work together are sometimes paid about a shilling a day each, by some man a little better off, who employs them. The turf, cut into small pieces, is emptied out into the "spread-field," where it is left untouched for a few days. At the expiration of this time a number of women and children scatter the turf from the barrow-heaps, so as to cover the whole surface of the spread-field. The spread turf is allowed to remain exposed to the air for about a week, and is then collected into parcels of about six clods, or pieces, each: these are placed on end in a circle, and made to support each other mutually by meeting in a point at the top. Another rest of a week or ten days is made, after which the turf goes through the process of "rickling:" this consists in piling the turfs one above another on their sides, into a group called a rickle. After remaining in this state another fortnight, the turfs are "clamped;" that is, they are built up into stacks about twelve feet long, six high, and four wide.

The turf being gathered, and thus far prepared, there arises the difficulty consequent on bad roads and insufficient communication. The "drawing-home" is often obliged to be postponed for a long time, until the dry state of the roads will allow carts to approach the spread-field; and very often the men have to carry the turf on their backs in ricks or baskets. When at length brought home, it is built up into a large stack, thatched or covered over so as to preserve it from the weather. So humid is the climate, and so uncertain the drying of the turf, that it is requisite to cut in early spring the turf intended for the next winter's fuel. Besides the peat here alluded to, there is another procured from the softer parts of the bog after the firm turf has been removed. It is a kind of pasty mass—

half mud, half vegetable fibre—and when taken out and laid on the ground, is kneaded by the naked feet of men and women into a sort of dough. The mass is then moulded into shape, like loaves for the oven, by hand, and spread out on the ground; and the pieces thus formed, being partially dried and again kneaded, are built up into stacks or groups, where they remain till dry enough for use.

In Scotland a good deal has been done towards bringing the peat of that country into an available form. Instead of using the naked feet to press out the moisture from the peat, as in Ireland, the Scotch are gradually bringing into use some very ingenious machines, designed by Lord Willoughby and one or two other persons; in which the peat is exposed to an amount of pressure which dries it sufficiently for use in a very short space of time.

Composition-Fuel.

A remarkable degree of activity has been shown within the last few years in devising new kinds of fuel, which, being compounded of easily-procurable ingredients, shall be cheaper, or cleaner, or more portable, or more fitted for some particular purposes, than coal. In most of these compositions *bitumen* or *asphaltum* is one of the ingredients.

One of the substitutes for coal here alluded to brings into valuable use the small coal which (as we shall presently explain more at full) accumulates around and near the mouths of pits in the colliery districts. With this almost neglected material, Mr. Oram combines a singular variety of ingredients; such as dried mud, alluvial deposits, marl, clay, or any other earth containing vegetable matter; together with any one among several bituminous substances, such as mineral tar, coal-tar, gas-tar, mineral pitch, vegetable pitch, resin, asphaltum; or sawdust, coke-dust, or ashes. The selection is thus very wide; and any can be combined according to the facilities offered at the time. The liquid bituminous matters are used cold; the solid are melted and used hot; and the earthy components are pounded and mixed with the others, so as to form a composition which may be moulded into brick-shaped pieces.

Mr. Williams, a director of the Dublin Steam-Packet Company, has devised a kind of composite fuel in which peat is brought prominently into use. In one of his methods the peat-moss, when pressed nearly dry, is further dried with powdered limestone or mud. In another method he combines bituminous matter with peat; so as to produce, according to the details of the process, a brown combustible solid, denser than oak; or a charcoal, twice as compact as hard wood charcoal; or an artificial coal; or an artificial coke. Dr. Ure, in speaking of some of Mr. Williams's methods, remarks:—"But one of the most important results of Mr. Williams's invention is, that with two parts of pit-coal and two and a half of his factitious coal, the same steam-power is now obtained in navigating the Company's ships as with seventeen and a half of pit-coal alone, thereby saving thirty per cent. in the stowage of fuel. What a prospect is thus opened up of turning to admirable account the unprofitable bogs of Ireland, and of producing from their inexhaustible stores a superior fuel for every purpose of arts and engineering!"

It is pretty well known to those who watch the successive introduction of patents, that as soon as any invention is promulgated, in which a great variety of ingredients is available, numberless patents speedily follow, differing one from another only in slight details of mixture. Such has been the case in respect to artificial fuel. Year after year something "patent" appears, comprising from two or three to a dozen different ingredients; but the advantages attending them do not seem to have been very striking; and they die away soon after birth.

Coke and Charcoal Fuel.

The introduction of gas for the illumination of streets and buildings was one of the means of bringing into use that altered form of coal which we designate *coke.* When coals are kindled in a close vessel without access to air, the gaseous ingredients become driven off, and if allowed to leave their prison-house, and to undergo a certain kind of purification, they constitute the "street-gas" with which we are—happily—so well familiar in the present day. But the solid residue left in the vessel has not lost its power of burning: it still contains elements capable of yielding great heat when ignited, and is largely serviceable as coke.

If the gas-companies in London could procure coal at anything approaching to the cheap price charged in the North, they would attach small importance to the production of coke in their retorts; but the price of coal being necessarily high, under the commercial circumstances regulating the coal-trade in London, the quantity and quality of the coke produced are matters to which much attention is directed. Some kinds of coal are better fitted for the production of gas than of coke; others rather for coke than gas; and there is an intermediate balance of advantages which generally determines the selection.

In the smelting of iron, coke is used very largely, instead of coal, to avoid certain deleterious gases existing in coal; and the making of coke is one of the preliminary operations at smelting-works. In South Staffordshire, where iron-works are grouped as thickly as potteries are in North Staffordshire, the coke is made in a singular manner:—In an open spot of ground kept vacant for the purpose, coals are heaped up in a form somewhat resembling a bee-hive of large dimensions, and then set on fire; the top is covered with a layer of clay or other earthy substance, which will prevent the coal from bursting out too briskly into flame, and will cause it to smoulder till it assumes the form of coke. When a number of these miniature hills are watched from a distance, smoke is seen to rise from them in abundance; as also a flickering flame when anything occurs to disturb the earthy coating on the surface. In other districts a less wasteful process is followed, by the use of brick chambers or ovens constructed expressly for the purpose, such as are represented in Fig. 195. The coke-ovens here represented (of which there are several dozens arranged somewhat in an oval form) are brick structures eight or ten feet high, having a flat roof with an opening where the coals are introduced, and another opening in front for the removal of the coke. In these ovens the coal is kindled without access of air, and is deprived of its bituminous and more inflammable ingredients.

Charcoal bears some such relation to wood as coke does to coal; that is, it is produced by burning wood without free access of air. During this burning many of the most volatile elements of the wood fly off in the gaseous state, leaving the carbonaceous portion behind; and this constitutes charcoal.

In many of the more wooded parts of the Continent, the processes conducted by the charcoal-burners are nearly as follow:—Two or three families, uniting their labours in common, dwell in tents or temporary huts, near the spot chosen for the operations. The timber being felled and dried, it is built up into heaps for burning. A plot of ground is prepared, hard, dry, and solid: in the centre is placed a circle of sticks adjoining each other, and forming a vertical hollow cylinder three or four inches in diameter, by six feet high. Round this interior cylinder are ranged successive circles formed by sticks or logs from one to ten inches in diameter; large and small pieces being so interspersed as to lose as little space as possible; and the outermost circle being composed of brushwood. When the pile is built out to a diameter of twenty or thirty feet, a coating of turf is laid on, with the grassy side next to the wood; and dry earth is heaped up round the bottom of the pile. Three or four screens, formed of large hurdles well stuffed with brushwood, are also placed to protect the pile from the violence of the wind. The pile is next kindled by dropping lighted chips down the hollow cylinder in the centre, the chips being renewed from time to time until the pile is well ignited. The top is now closed in, and a few small holes are made for the exit of gas and smoke; these holes are made near the bottom, and as soon as the smoke ceases to issue from them, others are made a little higher up; and so on until all the gaseous products have gradually left the wood. The fire is lastly allowed to die away slowly, and the wood is by that time converted into charcoal.

Charcoal, as a fuel, is more closely connected with the smelting of metallic ores than with domestic uses.

Coal—its geological position.

At length we come to that most important of all kinds of fuel—*coal;* that kind which—whether regarded as to its extraordinary origin, its bounteous development in our own country, the social employments and usages to which its extraction from the earth gives rise, the vast shipping arrangements involved in its sale, the aid which it affords to every branch of manufacture, the spur which it has given to engineering talent (for both canals and railways owed their origin in England mainly to the necessity for facilitating the transport of coal), or the comfort which it diffuses around the domestic hearth—is in every way worthy of attention.

It is justly and elegantly said by Dr. Arnott, that "A person reflecting that heat is the magic power which vivifies nature, and that coal is what best gives heat for the endless purposes of human society, cannot without admiration think of the rich stores of coal which exist treasured up in the bowels of the earth for man's use. And Britain, in this respect, is singularly favoured. Her coal-mines are in effect mines of labour or power vastly more precious than the gold and silver mines of Peru; for they may be said to produce abundantly everything which labour and ingenuity can produce, and they have essentially contributed to make her mistress of the industry and commerce of the earth. Britain has become to the civilized world around nearly what an ordinary town is to the rural district in which it stands; and of this vast and glorious city the mines in question are the coal-cellars, stored, at the present rate of consumption, for about one thousand years; a supply which, as coming improvements in the arts of life will naturally bring economy of fuel, or substitution of other means to effect similar purposes—may be regarded as exhaustless." The progress of colliery-engineering since Dr. Arnott wrote this passage, fifteen or sixteen years ago, has shown that our mines are still more inexhaustible than was then supposed.

Before we glance at the position of coal with respect to other mineral deposits, as to relative super-position, it may be well to see what districts of England have up to the present time yielded coal in sufficient abundance and with sufficient ease to render it commercially profitable. By the adoption of different kinds of engraved lines and numbers, Fig. 196 may aid in illustrating this point.

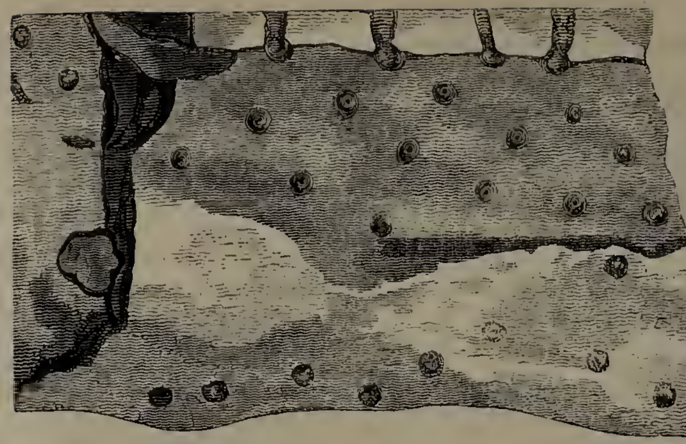
We shall find that a waving line Z Z, drawn from about Stockton in the north to Lyme Regis in the south, separates England and Wales into two parts, of which the north-western contains all our coal-mines; while the south-eastern, if it contain any coal at all, presents none which are so commercially valuable as to render them workable with profit, owing to the geological position of the various strata. In the map the *darkest* spaces represent the "coal-fields," or those districts where coal is more or less found interstratified with other mineral deposits; the lighter shades represent the districts which surround, and which are supplied by, the coal-fields. The white spaces are those farthest removed from the mines, and are supplied with coal by shipping. Before the railway system became developed, every town in the kingdom obtained its supply of coal pretty generally from one particular coal-field, the distance and the facilities of transport by canal determining the source of supply. Railways bid fair to overthrow this arrangement to a great extent; but in 1830 it was possible to construct a map showing the extent of the districts supplied from each coal-field. Our figure is a copy from such a map, and may be thus explained:—There are irregular boundary-lines to each district, and the districts themselves are represented by lines varying in direction for distinctness of separation. Now the black district near the top, marked I., shows the Northumberland and Durham coal-fields; while the extensive white portion I. along the eastern and southern coasts is supplied mainly by shipping bringing coals from Northumberland and Durham. II. is the Yorkshire, Nottinghamshire, and Derbyshire coal-field, supplying a district reaching from about Northampton to York. III. is the Whitehaven field, supplying Cumberland and a portion of the neighbouring districts. IV. is the South-Lancashire field, supplying our great cotton districts. V. the North Staffordshire, yielding an abundant supply for the collieries. VI. the South Staffordshire, containing the thickest seams of coal in England, and supplying the vast iron-works of the district. VII. the Shropshire and Coalbrook-Dale field. VIII. the Forest of Dean field. IX. the Bristol and South Gloucestershire. X. the Somersetshire. XI. the North Wales. And XII. the South Wales coal-fields. In all these cases the darker shade represents the coal-field itself, and the lighter the district (until now) supplied therefrom.

In order to render these details more familiar, the positions of thirty-seven cities and towns are indicated by figures, as follow:—

1 Newcastle	14 Leicester	26 Dover
2 North Shields	15 Northampton	27 Canterbury
3 South Shields	16 Shrewsbury	28 Maidstone
4 Sunderland	17 Birmingham	29 Hastings
5 Durham	18 Oxford	30 Brighton
6 Cockermouth	19 Gloucester	31 Portsmouth
7 Whitehaven	20 Windsor	32 Exeter
8 Lancaster	21 Bristol	33 Plymouth
9 Liverpool	22 Bath	34 Falmouth
10 Manchester	23 Colchester	35 Caernarvon
11 Scarborough	24 Bedford	36 Cardigan
12 Derby	25 Cambridge	37 Caermarthen.
13 Nottingham		

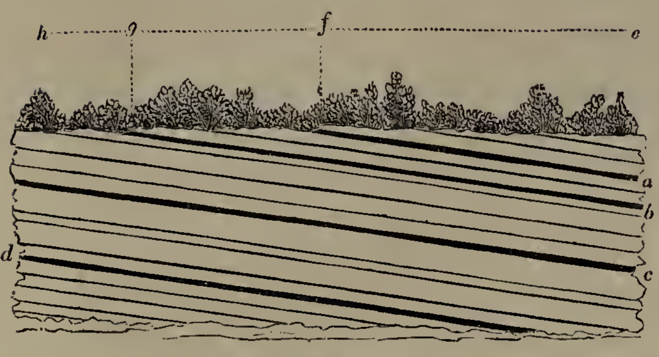
Over all these districts, *i. e.* those which have the dark tints representing coal-fields, coal is found to a greater or less extent, interstratified with other deposits. The coal lies in seams or beds, varying greatly in thickness. Sometimes there is only one seam in one spot; while in others there are several seams, at different depths from the surface of the ground, and having other deposits between them. A recorded example, which occurred in sinking a pit or coal-mine in Northumberland, will illustrate this in an interesting manner. The diggers first penetrated through clay to a depth of 102 feet; then through sandstone 42 feet; then they came to a seam of coal, only eight inches thick; this passed, they dug successively through twenty-nine different strata or layers of sandstone and shale, varying from forty inches to thirty feet, interstratified with eight seams of coal, from five to eighteen inches in thickness, and amounting altogether to 418 feet of thickness; then they came to the chief seam of coal, nearly seven feet thick; next through fifty-two beds of sandstone and shale, interlying with nineteen seams of coal, the aggregate thickness of the whole being 503 feet; then they came to a seam about three feet thick; and lastly through fourteen alternations of stone and coal, having a thickness of 82 feet. The result, then, was this; that in digging to a depth of 1158 feet, they passed through a hundred and twenty-five different strata, of which thirty-two

201.—Cyclopteris orbicularis—fossil plant in Coal.

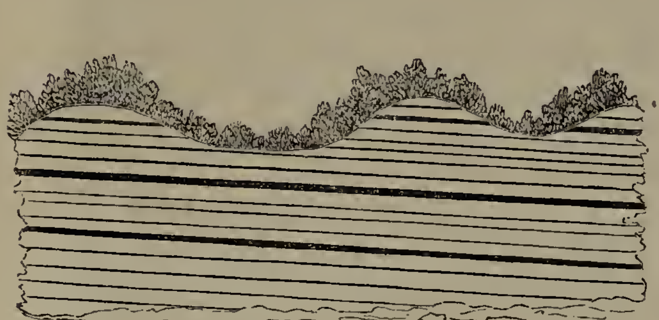


202.—Stigmaria Ficoides—fossil plant in Coal.

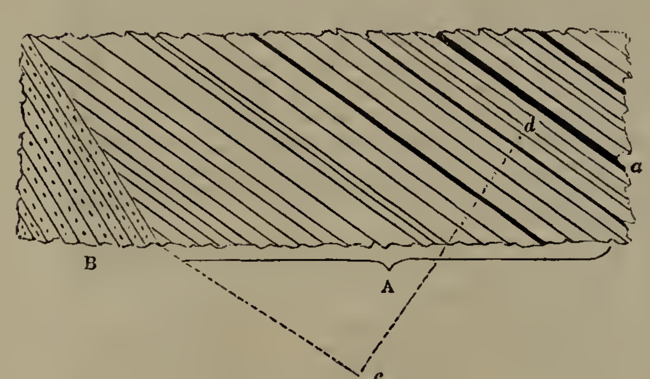
203.—Lonchopteris Bricii—fossil plant in Coal.



197.—Coal-stratification.



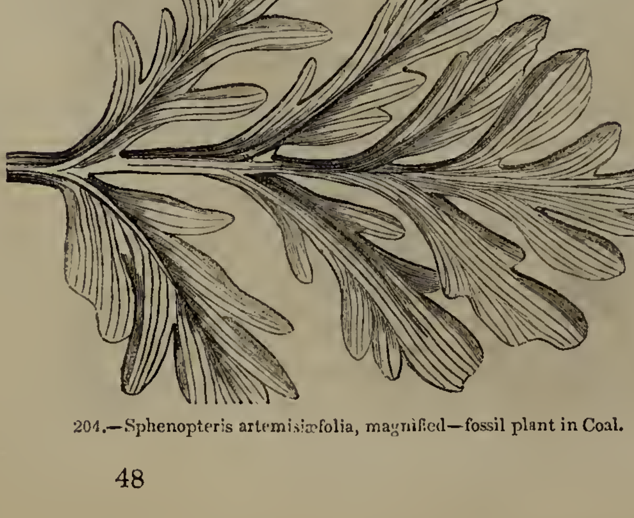
198.—Coal-stratification.



199.—Coal-stratification.

200.—Coal-stratification.

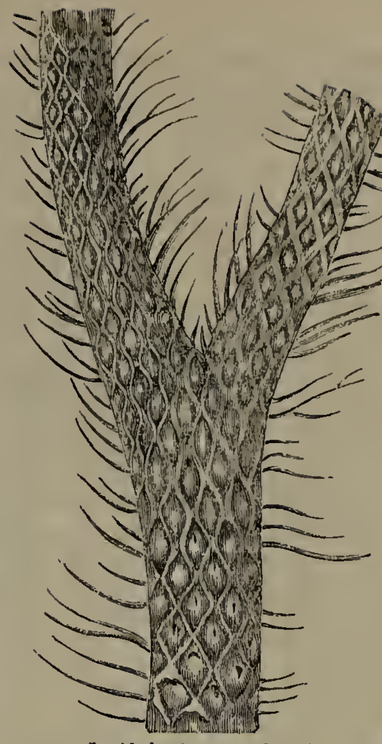
196.—Map to illustrate the Coal districts of England and Wales.



204.—Sphenopteris artemisiæfolia, magnified—fossil plant in Coal.

205.—Odontopteris Brardii—fossil plant in Coal.

206.—Neuropteris gigantea—fossil plant in Coal.



207.—Lepidodendron Sternbergii (fossil plant in coal).

208.—Lepidostrobus variabilis (fossil plant in coal).

209.—Calamites dubius (fossil plant in coal).

210.—Trigonocarpum Noggerathi (fossil plant in coal).

211.—Sigillaria reniformis (fossil plant in coal).

212.—Fossil-tree at Craigleith Quarry.

213.—South Hetton Colliery, Durham.

214.—Mechanism and Arrangements at the Mouth of a Coal-pit.

were coal, varying from five inches to seven feet in thickness. This will give some idea of what constitutes a coal-field.

Some of these coal-seems lie very much inclined, so that the same seam may be at very different depths under ground in different parts. The seam, too, often varies very greatly in thickness; being several feet thick in one part, and thinning out in another so much as to be scarcely worth working. The intervening beds of stone, in like manner, vary greatly in thickness; so that the miner is subject to various sources of uncertainty in his search for coal. Before geology became a science, this uncertainty was much greater, because it was not then known that the "coal-measures," or groups of coal-seams interstratified with other layers, always bear a certain definite relation to the other great formations of the earth's surface: this increase of knowledge has been since obtained; and colliery engineering has in consequence assumed a wider and more certain range. The geological position here alluded to may be thus elucidated:—The rocks and strata composing the crust of the earth are divided, for convenience, into *recent*, *tertiary*, *secondary*, and *primary* strata. The *recent*, being those (as is believed) of latest formation, comprise various sorts of sand, clay, and gravel, and contain the bones of animals of the same species as now exist. The *tertiary*, of later formation, comprise various strata of limestones, clays, pebbles, &c., containing numerous varieties of sea-shells, and bones of animals belonging to species no longer found on the earth. The *secondary* comprise chalk, flint, marl, sandstones, and limestones of various kinds. The *primary* consist of slate and many other of the hardest rocks, wholly destitute of any symptoms of organic remains. Now it is among the *secondary* strata, with many kinds of limestone above it and sandstone beneath it, that COAL is found.

The inclined position of the strata gives rise to many peculiarities in mining operations. Thus (Fig. 197) *a b c d* may be four seams of coal, lying in an inclined position, and interstratified with various other deposits. Now if a miner were to dig vertically at about the point *e*, he would have to go some distance before meeting with any one of the seams; if at *f*, he would find one immediately at the surface; if at *g*, another one at the surface; while at *h* he would be worse off than even at *e*. Again, in Fig. 198, where the ground is represented as having an undulating surface, some of the seams "crop out" almost horizontally into the valleys, while others are beneath both the valleys and the elevations. Fig. 199 shows a method by which the mining engineers determine roughly the thickness of the various strata. Having observed the general inclination of all the strata A, of which *a a* is a coal-seam, and also the inclination of another kind of rock, B *b*, which lies at a different angle, they are able, by a little calculation, to determine the length of the line *c d*, equivalent to the thickness of the strata associated with the coal: it is by this means that the depth of unattainable strata is approximately determined. Sometimes, as in Fig. 200, the strata have been so disrupted by internal convulsions of the ground, as to assume various curved positions, cropping out to the surface in very tortuous ways.

Fossil Plants found in Coal.

When we glance at the next twelve woodcuts (Figs. 201 to 212) we see some of the evidence which has led geologists to the opinion that coal is of vegetable origin. These represent either actual plants interspersed with and among the coal, or *impressions* of plants, more or less distinct and developed. These impressions occur generally in the "shale" of the coal-measures; that is, in the layers of hardened mud which separate the seams of coal; some occur in the coal-seams themselves, but these are not so numerous or well defined as those met with in the shale. Some of these vestiges of a period so far distant as to be beyond the reach of human records are described as being exceedingly beautiful. Thus, Dr. Buckland, in speaking of the coal-mines of Bohemia, says, "The finest example I have ever witnessed is that of the coal-mines of Bohemia. The most elaborate imitations of living foliage upon the painted ceilings of Italian palaces bear no comparison with the beauteous profusion of extinct vegetable forms with which the galleries of these instructive coal-mines are overhung. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of most graceful foliage, flung in wild, irregular profusion over every portion of its surface. The effect is heightened by the contrast of the coal-black colour of these vegetables with the light groundwork of the rock to which they are attached. The spectator feels himself transported, as if by enchantment, into the forests of another world; he beholds trees, of forms and characters now unknown upon the surface of the earth, presented to his senses almost in the beauty and vigour of their primeval life; their scaly stems and bending branches, with their delicate apparatus of foliage, are all spread forth before him, little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation, which began and terminated in times of which these relics are the infallible historians."

In most cases these impressions are of leaves separated from their branches, or of trunks more or less in a broken state. Sometimes portions of trees occur in which the vegetable texture is still observable. The leaves are mostly mutilated, and the leaflets of compound leaves severed; flowers are rarely if ever met with; and if fruit occur, it is not in clusters, but separated individually. All the woody portions have the appearance of having been decayed before they produced the impression in the shale, for the bark seems gone, and the convexity of the trunk flattened.

It has been found by naturalists very difficult to fix with any degree of precision the nature of the plants which produce these impressions; but they are divided, for convenience of reference, into three classes: viz., those of which only wood still containing organic structure has been found; those which have an obvious analogy with recent plants; and those with which no existing analogy has been traced. By means of preparing fossil wood in a particular way, and subjecting it to microscopic examination, it has been found that wood still preserving its texture exists in a mineral state extensively throughout the coal-mines of the north; that in most cases it has a structure analogous to, though not identical with, that of recent coniferous wood; and that, in cases where its structure is not coniferous, it is unlike that of any existing trees. The print of some kinds of palms is occasionally found, separated from each other, as if the bunches of the fruit had lain in water till the pulpy parts rotted away and the nuts fell asunder and settled down into the mud. Some of the plant impressions are closely covered either with diamond-shaped spaces disposed in a spiral manner, or by small scale-like leaves, which are supposed to have produced those spaces by falling off.

The most abundant of these impressions are those of ferns, comprising more than half of the entire species. The fruit is very seldom found with them; a circumstance which has added to the difficulty of determining their character. Many of the plants consist of short-jointed fragments, with channels furrowed in their sides, and are sometimes partly surrounded by a bituminous coating; they are supposed to have been originally hollow, but to have been subsequently filled up with the substance which fossilized them.

The few examples which our figures give will show the great diversity observable in the plants thus imbedded; whether they be mere impressions of the plants transferred to the substance of what was once a kind of mud, or the plants themselves fossilized into a more or less stony state. The occurrence of these, then, leads us at once to notice the

Probable Origin of Coal.

Although the shining, caking coal, with which we are so familiar, seems much more like stone than wood; yet, when extremely thin slices of it are exposed to the test of a strong microscope, they are found to exhibit a fine distinct net-like structure. The small fragments of coal, when examined simply by the eye, often exhibit some analogy to woody structures. The plants of which we have just spoken do not often yield specimens of wood having any great bulk; but occasionally there are instances come to light which bear very closely on the probable origin of coal. Trunks of trees fifty or sixty feet long, and preserving their woody texture throughout nearly their whole length, have been found imbedded in coal. On one occasion, near Newcastle, a stem was found measuring upwards of seventy feet in length, by four feet diameter at its thickest end; it was in a compressed state, as if flattened by great pressure: the woody structure was only in part preserved, and in those places it was converted into a kind of flinty petrifaction, containing cavities lined with rock-crystal. In another instance, in the great freestone-quarry at Craigleith, near Edinburgh, a branchless trunk nearly fifty feet long was found imbedded in the solid stone; when laid bare (Fig. 212) the bark was found to be converted into *coal*, but in the interior the woody texture is found to be well preserved in many parts.

This intimate connexion between coal and plants has led, after many different theories, to the following general opinion on the part of modern geologists. It is supposed that the numerous beds of coal have been formed by vast numbers of plants carried down from the land and accumulated at the bottom of the sea during a long succession of ages; sand, plants, gravel, and other deposits being accumulated in succession, and made to overlie one another. This supposition is founded on analogy with what is known to be going on at the present day. Rivers carry down to the sea more or less of the trees and plants which either fall accidentally into them or are swept from the banks by the force or undermining action of the stream; and these masses of vegetable matter accumulate at the mouths of large rivers in vast quantity. In the Mississippi, for example, vast bodies of trees are borne down along the bosom of the waters towards the Gulf of Mexico, and are there destined to produce results which, to future ages, may be of vast importance.

But it has yet to be seen how this bears on the matter before us. Even supposing that trunks of trees do thus accumulate at the bottom of the sea, what has this to do with the formation of coal? The researches of Dr. M'Culloch and others have shown that the action of water on turf or submerged wood is sufficient to convert them into a bituminous substance bearing some remote analogy to coal; and the following description of the substances forming the peat-bogs of Ireland, given by surveyors who, in 1810, examined them by order of Parliament, will strikingly show some of the stages intermediate between wood and coal. The bogs of Ireland are described as "a mass of the peculiar substance called peat, of the average thickness of twenty-five feet, nowhere less than twelve, nor found to exceed forty-two; this substance varying materially in its appearance and properties in proportion to the depth at which it lies. The upper surface is covered with moss of various species, and to the depth of about ten feet is composed of a mass of the fibres of similar vegetables in different stages of decomposition, proportional to their depth from the surface; generally, however, too open in their texture to be applied to the purposes of fuel. Below this lies generally a light blackish-brown turf, containing the fibres of moss, still visible though not perfect, and extending perhaps to a further depth of ten feet under this. At a greater depth the fibres of vegetable matter cease to be visible, the colour of the turf becomes blacker, and the substance much more compact, its properties as fuel more valuable, and gradually increasing in the degree of blackness and compactness proportionate to its depth. Near the bottom of the bog it forms a black mass, which when dry bears a strong resemblance to pitch or bituminous coal, having a conchoïdal (shell-like) fracture in every direction, with a black shining lustre, and susceptible of receiving a considerable polish."

This account is very instructive, as it gives us some insight into the possible way in which trees and plants may have been converted into coal. Our coal-beds may be either submerged forests, which by some convulsion of nature became covered with water, and after remaining so for ages gave place to a second convulsion, by which the coal districts became again dry land; or else they may have been lakes in depressed portions of country, into which drifted trees and plants became conveyed, there to be submerged for ages beneath a body of water. Whatever theory of distribution and deposition may be advanced, however, there seems the strongest evidence that coal, by some means or other, has been derived from plants acted on by water and pressure; and that the bogs still existing indicate different stages of an analogous process of conversion.

Collieries and the Colliery-system.

The beds of coal, let them have been formed how they may, lie more or less approaching to a horizontal position; and we have next to see how the pick-axe and the shovel, the industry and ingenuity of the miner, bring forth the mineral riches to the light of day. Many circumstances influence the mode in which this is effected: the thickness of the seams, the depth beneath the ground, the quality of the coal, the presence or absence of water in the neighbouring strata, the facilities for intercommunication—all take part in determining the system on which the operations are conducted.

"The traveller who visits for the first time an extensive coal-district," says an eye-witness, "will be struck by the vast canopies of smoke continually rolling their sluggish course in the direction of the wind. This smoke arises from the engine-fires and from the small coal burned at the mouth of the pit. On the clearest day these fires impart a cloudy aspect to the landscape. If a visit to the great northern coal-district be the object of the traveller's journey, he will find on the road from Newcastle to Durham, which is an elevated and rising ground, a series of magnificent views successively burst upon him, almost unequalled in any part of England. At intervals, as he ascends, a wider horizon spreads out before him, the hills are bold and picturesque, and occasionally exhibit in their sweeping outlines combinations of unusual grandeur. When he at length reaches the coal-fields, he will find the face of the country black and blasted; and that appearance, united with the perpetual clatter of the waggon-trains, may fill him with somewhat gloomy feelings. When the first impressions of the traveller have subsided, and he looks more narrowly at surrounding objects, he cannot fail to be strongly impressed with the vastness and extent of the commercial enterprise of the district. On every side rise extensive buildings; and in the centre of each, one more lofty than the rest contains that mighty power which has created by its effects more than one-half of this sphere of human activity. These buildings are the works connected with the collieries."—*Penny Magazine*, vol. iv.

The South Hetton colliery (Fig. 213) will well illustrate the rapid progress of this department of national industry. Fifteen or twenty years ago it was a barren spot distant from every or any kind of habitation; but in a space of about five or six years the opening of new coal-mines established a village of two

thousand inhabitants, and gave all the customary features of commercial bustle to that which had so recently been an uninhabited spot.

The coal obtained from the various mines differs much in quality; the kind called *stone-coal* or *splent-coal* has a less proportion of bitumen than the others, and by being intermixed with much earthy matter, yields a large quantity of ashes. Another kind is the *caking-coal*, the prevalent quality in Northumberland and Durham. A third sort is called in England *cannel-coal*, and in Scotland *parrot-coal*—it has a very close compact texture, is hard and splintery, crackles in the fire, and burns with a very bright flame. Sometimes all three kinds are met with in the same mine.

Whatever be the variety of coal, it is always dug from a depth beneath the surface; and the greater or less amount of this depth determines much the relations and agreement between the owners, the lessees, and the workmen in the mines. The beds or seams of coal are never, in this country, so near the surface as to be worked in open day like a stone-quarry; nor are they often met with in the side of a hill, so that the mining could be carried on in a horizontal direction. The miners employ the term "*winning*" to the extraction of coal by means of mining; and when a coal-field is to be "won," a circular shaft like a great well is sunk, to serve both for the descent of the miners and for the ascent of the coal. A certain quantity of ground is leased or sold in respect to the coal lying beneath it; and the "winning" of this coal constitutes an extensive range of operation. Sometimes the capital required for this is too large for one individual safely to embark in it; and in such case a lease is taken by a company of "adventurers," as they are called. Among all the great mines in Northumberland and Durham, only a very small number are leased by individuals; the formation of joint-stock parties being the prevalent system. The capital of these companies is raised in shares of small nominal amount, which, being transferable, pass from hand to hand very frequently; so that a very large number of the inhabitants in those districts, having a little money to spare, are practically coal-owners. Some collieries can be worked with a capital of 10,000*l.*; while others require a capital of 150,000*l.* These differences arise, not only from the depth at which the coal lies, and the facilities for bringing the produce to market, but to the existence of quicksands and of watery strata, which require both an additional amount of apparatus in the mine itself, and an additional shaft for pumping up the water before the coal can be reached. Some of the coal-seams are not more than forty feet deep; while others considerably exceed a thousand; and it is easy to see how this variation of depth affects the amount of capital requisite to "win" the coals.

The proprietor of the land and the company of adventurers enter into leases and agreements in the way just stated; and the adventurers then arrange with the miners who are to do the work. The pitmen are generally engaged for a year, at a stipulated weekly wage, which they are to receive whether the works proceed rapidly and favourably or otherwise. The employers generally provide a dwelling and a sufficient supply of coals for the miners beyond the wages. The men are generally employed about eight or ten hours a day; and in extensive collieries there are different sets or "shifts" of men, so that the works may proceed uninterruptedly. As an example of the minute subdivision observable among the persons engaged in collieries, the following may be cited in relation to an establishment employing 526 persons.

OFFICERS.

Manager	[Commonly called Agents]	1
Viewer		1
First Engineer		1
Second Engineer		1
Surgeon		1
Clerks		4

WORKMEN ABOVE PIT.

Joiners and Sawyers. (These men keep the works in repair.)	13
Engine-Wrights. (Repair and make the machinery.)	7
Engine-Men. (Keep the machinery in action.)	8
Firemen. (Attend the boilers.)	9
Smiths. (Prepare the iron-work in the rough.)	18
Masons	8
Labourers to do.	6
Cartmen	11
Horsemen	9
Saddler	1
Waggonway-Wrights. (Lay down and mend the rails on the rail-roads, &c.)	6
Waggon-Riders. (Conductors of the waggons, of which there is one to each train)	11
Staithmen. (Attend at the staith to empty the waggons of their coals into the ships.)	4
Banksmen, who deliver the corves	8
Waggon-Fillers and Screeners	12
Wailers. (Boys who pick out the stones and otherwise clean the coals.)	9
Carried forward	149

Brought forward	149
Corvers or Basket-makers	4
Heap-keeper. (Looks after the quality of the clean Coals.)	1
Store-keeper. (This man presides over a vast magazine of stores, which he delivers to the men as they are wanted.)	1
Attendants on Railway, including Engineers and Furnace-men	8
Trimmers. (Men who fill up the holds of vessels with the coal discharged into them from the staiths.)	8
Boys for sundry purposes	39
WORKMEN IN THE PIT.	
Hewers. (Miners who "hew" out and blast the coal.)	140
Putters, who "put" the corves on the trains: Dragmen and Foals, who draw them to the bottom of the shaft; Helpers-up and Trappers, who manage the ventilating doors	140
Deputies or Foremen; Ventilators, Shifters, or Pit-Masons, &c.	36
TOTAL	526

Colliery Operations.

We shall now avail ourselves (in a condensed form) of the account, given in the volume lately quoted, of the chain of processes connected with the working of coal: this we do because that description was written by an eye-witness of the operations at one of the best and largest establishments in Durham.

In establishing a new colliery, the first thing done is to survey the surface ground: this is done by a *viewer*, who possesses scientific attainments and extensive practical knowledge, since the amount of capital required in the enterprise depends greatly on the success with which he makes his examination and calculation. In times when the viewers knew less of geology than they do now, fifty thousand pounds have sometimes been wasted without reaching any coal at all! But those times are past; for it is now known that coal bears a certain geological position in relation to other deposits.

The spot being determined on, the sinking of the shaft is commenced; and a steam-engine is erected on the spot, for the purpose of working the pumps which draw off the water, and also for drawing up the materials excavated below. Every aperture at which water enters the pit is carefully noted, and is stopped when practicable by a barrier called "cribbing," or "tubbing." The shaft is lined with strong boarding or brickwork, which is progressively done as the work advances. Where the pit is a thousand feet deep, as sometimes occurs, the labour of sinking it is immense, and the men are in much danger from the irruption of water and the accumulation of bad air. While the shaft is being sunk, the necessary buildings are in course of erection, and the machines and apparatus for "winning the coal" are prepared. A platform is laid down round the mouth of the pit, about twelve feet above the level of the ground, called a "bank," or "bank-top," upon which the coal is landed. A powerful apparatus is affixed to two or more steam-engines for raising the coal; large pumps are applied for drawing off the water; ventilating fires and draught-doors are prepared for exhausting the foul air of the pit, and supplying it with a current of fresh air; railroads for the conveyance of coal to the nearest harbour or railway station are laid down; houses are built for the accommodation of the workpeople; and when all these subordinate arrangements are finished, a day is fixed for bringing the first "coal to bank." The neighbouring country people assemble on the occasion; and the opening of the pit, the "winning" of the coal, and the starting of the first train of waggons, is celebrated as a sort of colliery "harvest-home."

The pumping of the water was at one time performed by men or horses; a method so ineffective that the working of a deep pit was almost impracticable. Water-wheels were introduced about the year 1680, and greatly facilitated the object in view. Rather more than a century ago Newcomen introduced his steam-engine; and this, though of very humble pretensions, was the precursor to the splendid train of machines which the genius of Watt and others has brought to such high perfection. At the present day the largest engines are employed to draw up the water; while smaller ones draw up the tubs, buckets, or "corves" containing the coal, and raise and lower the miners. The vessels are drawn up by means of ropes of immense weight and power; and one of the modern improvements in the art has been the substitution of ropes made of plaited or twisted iron wire, for the usual hempen ropes. The mouth of the pit presents some such appearance as Fig. 214, where various kinds of apparatus are seen, some suspended and others fixed. In the first place there is the pit or shaft, down which two men are about to descend in a kind of tub *c*, suspended from a chain and rope which are worked by a steam-engine above. At *a* are baskets which have just been drawn up filled with coals, and are about to be emptied; *b* is a curious substitute for a *bell*, which, being worked by the miners below in the pit, through the intervention of a chain, strikes a blow with a hammer, audible enough to act as a signal. Suspended from a beam is a large open kind of grate containing blazing coal to give light around; and at *d* is an opening through which the coals are thrown into a receptacle beneath, of which we shall have to speak in a future paragraph.

At the bottom of the shaft are the horizontal galleries and excavations from which the coal is dug by the miners. Figs. 215, 216, and 217 may represent such a gallery or "way" eight feet high by fourteen wide. The bottom or floor is called by the miners the "thill," and the top the "roof." In these galleries the miners or "hewers" carry on their work in pairs, each taking about twelve feet of the side-wall to excavate, and leaving between the spaces an interval of the same width, on which the roof may securely rest. The first process is to form a "board," which is done by digging out the coal from the bottom with a pick to a depth of three or four feet. This "board" is next formed into a "judd" by picking away the sides in the same manner as the bottom had been loosened; so that there is thus formed a projecting mass of coal eleven feet long by six high. In this judd a deep sloping hole is bored, which is filled with gunpowder and fired by a train: a process which shivers the judd into large fragments, and scatters them over the floor. In this way much labour is saved; and larger-sized masses of coal are procured for the market. As the coal-seams vary from two to thirty feet in thickness, the arrangements necessarily vary in detail; but we mention a thickness of six or seven feet as a convenient average. Sometimes seams are wrought only twelve inches in thickness, and require the aid of boys. Many of the sad and repulsive details contained in the Report of the Commissioners concerning Coal-mines, two or three years ago, arose as much from the narrowness of the seams worked as from any other cause.

When the coal has been loosened and blasted into fragments, a basket or "corve" is brought to the spot on a four-wheeled train by a man and boy, technically termed the "dragsman and foal;" and when filled with the scattered fragments, this corve is dragged to the bottom of the shaft, hooked to the end of the rope, and drawn up to the pit-mouth. When the corves are made of iron, they are called "tubs," and the labours of the dragsman and his assistant are then performed by horses.

The very deep coal-pits are seldom visited out of curiosity; a mingled dread of danger, of moisture, of dirt, of dreariness, tending to check the desire so to do. "Yet," as Mr. Holland aptly remarks, "these considerations and inconveniences overcome (and they are often greater in imagination than reality), there are few sights more striking to an eye unaccustomed to subterranean mining operations than are presented by those immense caverns, or apparently interminable galleries, in which the pitman pursues,

"Howe'er the daylight smile, or night-storms rave,
His dangerous labour, deeper than the grave;
Alike to him whose taper's flickering ray
Creates a dubious subterranean day,
Or whether climbs the sun his noontide track,
Or starless midnight reigns in coif of black;
Intrepid still—though buried at his work,
Where ambush'd deaths and hidden dangers lurk."

. . . . But if courage be required to enter a coal-mine at ordinary depths, it is in descending the frightfully deep pits in the neighbourhood of Newcastle that sensations bordering on the awful are inevitably experienced; and in traversing at such profound depths the endless galleries into which the shafts ramify, the visitor is struck by the perfection of plans adopted to lessen, as much as possible, the risk which the pitman runs in situations where the great value of the coal induces them to get it as completely as possible. On the other hand, the vast caverns formed in getting the thick Staffordshire coal, exhibit on a much more striking scale the combined operations of the miners, from the space which, when artificially illuminated, the eye commands at once; at the same time that persons may move about more commodiously, and also with fewer apprehensions of danger from explosions or foul air."

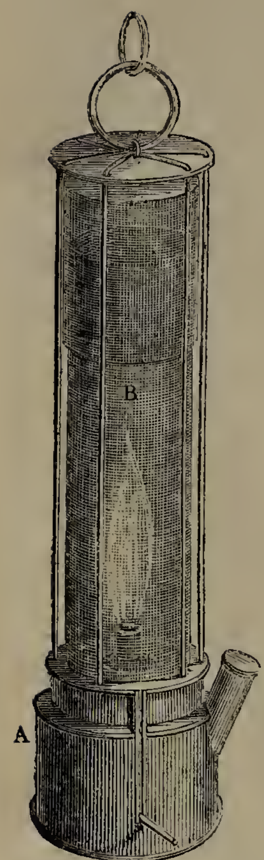
Lighting and Ventilating the Mines.

Before following the coals to their destination, it may be well to say a little more concerning the place where the miners grope away so large a portion of their existence, and the miners themselves.

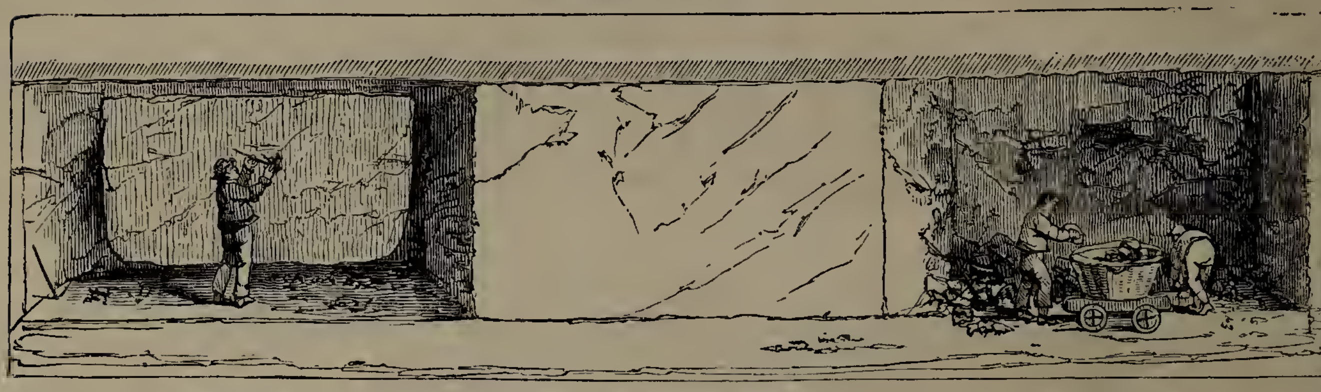
The explosions of inflammable gas, or "fire-damp," in coal-mines, which are even now occasionally heard of, used to be much more frequent. They arise from the following circumstances:—All coal contains in its natural state, while underground, a considerable quantity of free uncombined gas, which it parts with when exposed to the air, or when it is relieved from great superincumbent pressure. The gas is evolved from the coal in great quantity at the ordinary temperature of the mines; and as there are numerous fissures in the roofs of the "ways" or excavations, sometimes extending for miles, they may be regarded as natural gasometers, in which the gas accumulates to a highly condensed state. Coals lying deep give out more of this

Pitmen forming a "bord." Dragsman and Foal. Forming a "judd."

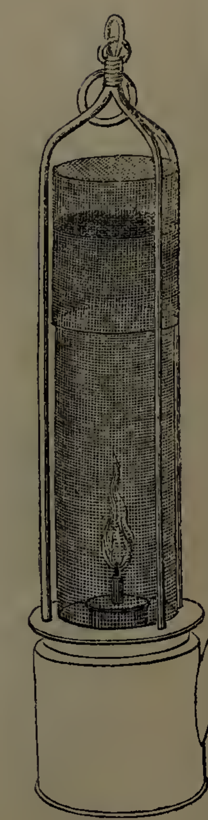
215.—Coal-working in the Mine.



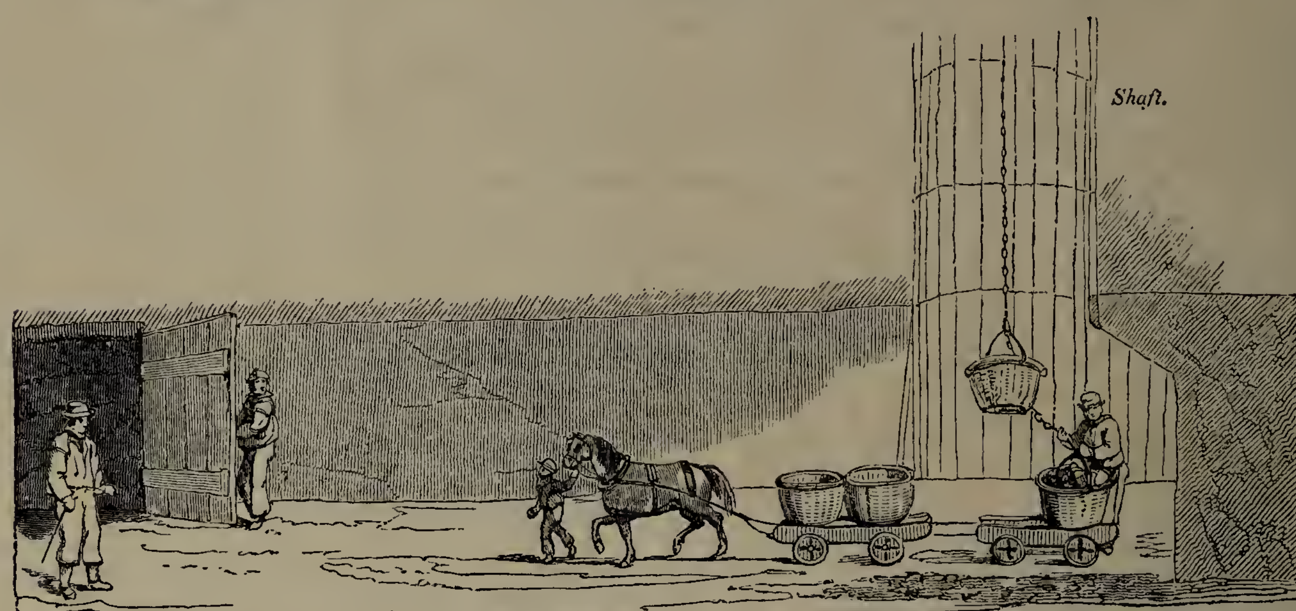
218.—Safety Lamp.



Preparing to blast. 216.—Coal-working in the Mine. Gathering the Coal.



219.—Safety Lamp.



Ventilators. 217.—Coal-working in the Mine. Corves about to ascend the Shaft.

220.—Miner, with the Safety Lamp.

221.—Staffordshire Colliers.

222.—Seaham Harbour Coal-Staith.—Mode of shipping Coal by the "Spout."

224.—Coal-Railway from South Hetton to Seaham Harbour, with the ascending and descending Trains.

223.—Screening Coals into different qualities.

225.—Seaham Harbour, at the Termination of the South Hetton Railway.

226.—View on the Tyne, showing the mode of shipping Coal by the "Spout."

gas than those near the surface, because there are openings at the surface by which the latter may escape; whereas in deep mines it cannot have such an outlet, and therefore it accumulates there most largely. In the course of working the coal the miners sometimes cut across one of the fissures, or approach so near to it that the intervening rock or shale becomes too weak to resist the elastic force of the condensed gas: it gives way, and the gas rushes out with immense force.

The gas thus emitted has these precarious qualities: that when kindled as a jet issuing from the coal, it burns with a bright flame like ordinary gas; but when mixed with a certain proportion of atmospheric air, it becomes explosive, and is then highly dangerous. If the proportion of gas to air be more than one to about fourteen, a liability to this explosion ensues; and hence the mining engineers endeavour to make such arrangements as may keep below the dangerous ratio. They cannot lessen the quantity of gas issuing from the coal, but they can increase the quantity of fresh air admitted into the mine. Large fires are kept in some of the mines, constantly burning at the mouth of the ventilating shaft, which shall occasion a draft sufficient to carry up the foul air; and air-pumps are added to quicken the draught. In some cases the quantity of gas generated by the coal is so great as to require nearly twenty thousand cubic feet of atmospheric air to be forced into the mine every minute, to keep it in a safe working state. Doors are constructed across the various passages, at certain places, with the object of compelling the fresh air, which may be forced into the mine from above, to follow a certain track, and to pass through all the passages in succession, clearing out the foul air as it goes. Boys are kept to attend to these doors (as at the left-hand side of Fig. 217), whose duty it is to open the doors when a corve or coal-tub is about to pass, and to close it immediately afterwards.

Where there is no danger of "fire-damp" (as this dangerous gas is called) the miners work by the light of candles, stuck into a piece of moist clay; but where the fire-damp exists this mode is dangerous, since the flame of the candle will kindle the gas. The gas is not explosive without the presence of flame, and the men can work in it without feeling any inconvenience. The question is, therefore, how to have light enough to work by, without hazarding the ignition of the gas. In former times the miners used a "steel-mill," consisting of a small wheel of steel, six or seven inches in diameter, moved by a little toothed wheel with great velocity; when a piece of flint was held to this revolving steel, a stream of sparks was given out, yielding light enough for the miners, and being less dangerous than the flame of a candle. Still it *was* dangerous, and led to Sir Humphry Davy's beautiful invention of the safety lamp.

This lamp (Figs. 218, 219) depends on a very curious property of flame. Sir Humphry Davy, in a train of experiments on the "fire-damp," found that the flame produced by an explosion of this gas with common air would not pass through long narrow metallic tubes; and that this principle of security might also be obtained by diminishing the length and diameter of the tubes; so that a great number of small apertures would not allow the explosive agent to pass, if their diameter were equal to their length. This fact led to trials upon sieves made of wire-gauze; and he found that if a piece of such gauze were held over the flame of a lamp of coal-gas, the flame could not pass through the meshes; and he also ascertained that a flame confined in a cylinder of very fine wire-gauze did not explode even a mixture of oxygen and hydrogen, but that the gases burnt in it with great vivacity.

On these principles the miners' safety-lamp has been constructed. Fine wire-gauze, about a fiftieth of an inch in thickness, is woven with meshes about a twentieth of an inch square, and is then formed into a sort of cylinder about two inches in diameter. The cylinder is fastened to the lamp by a screw; and various minor arrangements are made for facilitating the supply of oil, the trimming of the wick, and the suspension of the lamp while working, without air being able to obtain access except through the meshes. The miner hangs this in a convenient place while at work (Fig. 220), and the appearance of the flame indicates the condition of the air in the mine. If the fire-damp be gradually increasing in the air which surrounds the lamp, the first effect is to increase the size and length of the flame; when the fire-damp forms as much as one-twelfth of the volume of the air, the cylinder becomes filled with a feeble blue flame, but the flame of the wick appears at the same time burning brightly within the blue flame: the light of the wick continues till the fire-damp increases to one-fifth or one-sixth, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light; when the foul air constitutes one-third of the atmosphere. Now the reason why the fire-damp, thus burning within the gauze cylinder, does not kindle and explode that which fills the mine generally, is simply this.—Flame is gaseous matter so intensely heated as to be luminous, and the temperature requisite for producing it exceeds that of the white heat of solids. When the flame comes into contact with wire-gauze, it loses so much heat in consequence of the conducting power of the metal which conveys it to the surrounding air, that it is cooled below the point at which the gaseous matter can remain luminous; and, consequently, the flame of the gas burning within the lamp is incapable of passing through it so as to kindle and explode the mixture of fire-damp and air by which it is surrounded; and this cooling power is exerted even though the wire-gauze is rendered and remains red-hot.

Many explosions have occurred in spite of the use of this admirably constructed lamp; but it is believed that the careless habits of the miners, rather than any defect in the lamp itself, have been the cause of these catastrophes.

The Colliers and their Characteristics.

The men who are exposed to the dark and rough life of a coal-pit must necessarily present many peculiarities. The same family, for many successive generations, are employed in the same way, and transmit a certain strongly-marked common likeness from one to another. If the seam of coal where the colliers work is of tolerable thickness, many of the men have good stalwart figures, as the employment fully develops all their muscles; but where the miner's labours are confined chiefly to narrow seams, his spine and legs often become crooked, from the awkward position in which he is obliged to work. From the peculiarity of the light to which they are exposed, the eyes assume a diminutive appearance, and the eyelids become swollen. As to their attire, the men sometimes work almost or quite without clothes, when the atmosphere of the mine is close and hot; but under ordinary circumstances they wear a kind of short coat and trowsers of flannel. The Northumberland and Durham pitmen's villages are described as being quite as characteristic as the men themselves. "The houses consist each of one room, with a washhouse behind, and a chamber over the whole, access being obtained to the latter by means of a ladder. About two hundred such abodes, ranged at irregular intervals alongside the road, constitute one of these hamlets. Heaps of ashes and other refuse are suffered to accumulate before the front and back doors; and upon these, during fine weather, a number of robust and half-clothed children, of an age too young to be employed at the works, are too often suffered to idle away the day. In front of every fifth or sixth house stands a bakehouse for common use, which contains a large brick-built oven. Early in the morning the wife and daughters of a pitman may be seen assembled there with sundry old gossips, to bake a week's bread for the family; and to a person who has no previous idea of the sharpness and extent of a pitman's appetite, the size of the loaves may perhaps be a matter of some astonishment. Before the front window of each tenement stands a pile of small coal, which is replenished every week by a gratuitous cart-load from the pit."

The Staffordshire colliers (Fig. 221), while they have just so much of local peculiarity as to give them a distinct position, have many of the hard features of character observable in those of the North. Their figures are generally tolerably robust; but their faces, when by any accident the coating of black dirt in which they are cased is partially rubbed off, appear ghastly pale, and even at an early age are ploughed with deep furrows. One of the oddest peculiarities in these men is the almost universal substitution of *nick-names* for regular surnames. A laughable example of this was given by a writer in the 'Quarterly Magazine' for 1822:—"The following I received from a respectable attorney. During his clerkship he was sent to serve some legal process on a man whose name and address were given to him with legal accuracy. He traversed the village to which he had been directed from end to end without success; and after spending many hours in the search, was about to abandon it in despair, when a young woman, who had witnessed his labours, kindly undertook to make inquiries for him, and began to hail her friends for that purpose.

"'Oy say, Bullyed, dost thee know a mon neamed Adam Green?'

"The Bull-head was shaken in sign of ignorance.

"'Loy-a-bed, dost thee?'

"Lie-a-bed's opportunities of making acquaintance had been rather limited, and he could not resolve the difficulty.

"'Stumpy' (a man with a wooden leg), 'Cowskin,' 'Spindle-shanks,' 'Cock-eye,' 'Pig-tail,' and 'Yellow-belly,' were severally invoked, but in vain; and the querist fell into a brown study, in which she remained for some time. At length, however, her eyes suddenly brightened, and, slapping one of her companions on the shoulder, she exclaimed triumphantly—'Dash my wig! whoy he means moy fayther!' And then, turning to the gentleman, she added—'Yo should'n ax'd for Ode Blackbird!'"

Transport and Shipment of Coal.

We have seen, then, whence the coal is procured, how dug, and by whom; and we have next to trace it to its destination.

When the corves and tubs, which bring the coal to the mouth of the pit, are safely landed on the "bank," they are emptied of their contents down one of a series of trap-doors, seen in the floor of the "bank" in Fig. 214. The coals roll down a long sloping sieve, or screen, to a stage below, as in Fig. 223, by which the large coal becomes separated from the small, for sale at very different prices. All the large Northumberland and Durham coal for the London market is so carefully sifted, that on leaving the pit it is almost perfectly free from dust and small particles. There is a place near Newcastle-upon-Tyne, called "Wall's End," being near the eastern termination of the wall which once stretched across Britain from east to west; and near this place are many collieries which have given some celebrity to the place. But when "Stewart's," and "Lambton's," and other kinds of "Wall's End" coal are advertised, it must not be taken as indicating that these coals were brought from thence; for many of the best of these mines are situated in the county of Durham. The meaning of the expression, as a technical term, is said to be this:—That when coals have been screened over a sieve whose meshes are five-eighths of an inch asunder, they obtain the name of "Wallsend coals," and are sold at the highest price; whereas if they have passed over a three-eighths screen they become "seconds." The refuse from the Wallsend gives, by further screening, another kind called "rusts;" and the remains of this screening become "dead small."

The screened coal is collected on a wooden stage, and shovelled into waggons which are brought underneath, which are each made to contain 53 cwts. While this is doing, several men and boys pick out any stone, slate, or other refuse with which the coal may happen to be mixed. The carts run upon railways, and the railways in most cases convey the carts down to some river or harbour. On the Tyne, the Wear, and the Tees, for example, there are numerous colliery railways running down to the banks of the rivers, along which trains of waggons move. If the railway is quite level, a locomotive often heads the train, and drags it to its destination; if there is a regular descent the whole way from the colliery to the harbour, the waggons are impelled by their own gravity, and, by the aid of a long rope and a series of pulleys, drag up the empty train, which, in its turn, when again descending with a load, draws the other up to the pit; when the railway is carried *up* an incline, the train is drawn up the ascent by a stationary engine. Sometimes a private estate intervenes between the colliery and the shipping-place, and in such case the colliery-owners have to pay an annual sum for the "right of way," or "way-leave," through the estate. Figs. 224, 225, will illustrate examples in which the descent of the laden waggons a little more than counterbalances the ascent of the empty waggons, by the inclination of the surface, so as to give an effective carrying power, but without the fearful velocity which an unchecked descent would give to the running mass.

The coals having, as we will suppose, arrived at the river-side, or the harbour, are precipitated into the vessel there moored by one of two methods; either by means of the *staith*, as shown in Fig. 226, or by the *spout*, as sketched in Fig. 222. It is principally in relation to the elevation of the banks that the one or the other of these two plans is chosen. In most of the collieries near the Tyne a large platform of wood, called a staith, is erected at the end of the railway, overhanging the river. Upon this platform the laden waggons are brought to a stand previous to the discharge of their contents into the holds of the ships. The waggons are placed one at a time on a square open frame, which, on the withdrawal of a bolt, is immediately moved from the staith by machinery, until it is suspended immediately over the main hatchway of the vessel. A man who descends with it then unfastens a latch at the bottom of the waggon, which, being made to turn upon hinges like a door, immediately opens, and the whole of the coal in the waggon is emptied into the hold. To facilitate this operation the sides of the waggons slope inwards towards the bottom, and are lined with smooth iron plates. Attached to the suspending machinery are two counterpoising weights, which, being less heavy than the waggon when laden with coal, do not impede but add steadiness to the descent; but when the coal is discharged, the weights being heavier than the empty waggons, the latter ascend, to be again wheeled along the railway and re-filled.

Where the height of the cliffs is too great to allow the coals to be conveniently shipped in this manner, a large wooden spout or shoot is used, through which the coal, emptied from the waggons, descends into the hold of the ship below.

There is a peculiarity in respect to the Tyne colliery arrangements, arising from the bridge at Newcastle being too low to allow vessels to pass under it. The collieries situated above bridge are obliged to employ light barges called "keels," which receive the coals from some point of the banks nearest to the pits, and convey them down the river to the ship. A Newcastle "keel" contains, by admeasurement, about eight chaldrons. The coals, when large, are piled in the vessel in the most convenient way; and when small,

deep side-boards are added, within which the coals are heaped. When the coal is tender and liable to break, it is placed in tubs, a sort of waggon without wheels, each containing a chaldron; eight of these are placed in a keel, and on being brought to the side of the ship, each tub is hauled up separately, and the contents emptied into the hold of the vessel. The keels are managed by men who, from the peculiarity of their occupation, form a distinct class at Newcastle, and have many characteristics. The great oar, which is used as a kind of rudder at the stern of the vessel, is called the "swape;" the poles with which the keelmen push on their keels in shallow water, when it is inconvenient to use sails or oars, are called "pugs." The expenses of keelage amount to about nine-pence per load or chaldron; and it is therefore an important matter when the coal-owner is enabled to dispense with the services of the keelmen. These men, however, have many points to recommend them; they raised by their own subscriptions a fund sufficient to build the "Keelmen's Hospital," one of the buildings of Newcastle, to afford an asylum for fifty-two aged men and women in their declining years. The institution is kept up mainly by the keelmen themselves; and at an annual meeting there is great rejoicing among them. The song of "Weel may the keel row" has its origin among the keelmen of the Tyne

The colliery vessels assemble at North and South Shields, and other places between Newcastle and the sea, to receive their cargoes of coal from the Tyne; at Sunderland to receive those from northern and central Durham, shipped at the Wear; and at Stockton and other places on the Tees, for the South Durham coal. The extent of traffic thus carried on is immense; and on the north and south banks of the Tyne may be seen huge hillocks which illustrate one of the peculiarities arising out of this trade: the hillocks here alluded to are "ballast-heaps." The coal, pottery, glass, and other products, exported in such immense quantities from the Tyne, have not an equivalent in bulk in the commodities sent from London; especially the colliery vessels, which are unfitted for the conveyance of other goods than coals. Whence results that the vessels which have taken coals up to London require a large quantity of ballast to place them in sailing order on their return voyage. This ballast is composed of river sand, obtained at a cheap rate from the dredging of the river; and when it has enabled the vessels to reach the Tyne, the purpose of the ballast has been answered. But the affair does not end here: the vessels must be emptied, and the ballast must be deposited somewhere: it could not be allowed to be thrown in the Tyne; and as the only resource, therefore, it has been deposited on the banks, where, in time, enormous heaps have accumulated; in some instances two or three hundred feet in height. So important is the proper regulation of this matter deemed to be, that a district has been purchased within the last few years on the sea-shore, and a railway a mile in length constructed from thence to South Shields, as a means of depositing, in a spot not required for other objects, the ballast taken out of the Tyne shipping. The owners of the vessels pay a certain price per ton for the space thus occupied by all the ballast thus discharged.

Coal-Trade and Consumption.

Every one must be prepared to believe that the consumption of coal in England is very large. The habits of the people as to the use of coal-fires, and the immense consumption of this fuel, either in this form or in the transformed state of coke, for manufactories, steam-boats, locomotives, and other purposes, necessarily lead to a demand which, unless our mines were incalculably rich, would be a subject for alarm. The more the matter is investigated, however, the less reason does there appear to be for apprehension as to the failure of supply.

The records as to trading in coal in this country extend back to a period of about six centuries. Henry III. granted a charter for digging coal, and forty years afterwards Newcastle was celebrated as a centre of the coal-trade. In the early part of the fourteenth century the use of coal was prohibited in London, on account of the supposed effect which it had in rendering the air impure and unwholesome; but experience showed by degrees that this fear was not borne out, and the use of this fuel gained ground more and more over that of charcoal and wood. In the latter part of the same century a duty of sixpence per ton was levied on ships coming to London from Newcastle with coals, and a duty was also levied about the same time, by the corporation of Newcastle, on the ships leaving their port. From time to time new regulations were made, arising out of the great increase of the consumption, until at length they assumed rather a complicated state. A considerable revenue was for many years raised from all coal carried coastwise by sea from one part of the kingdom to another. This tax, imposed during the reign of William and Mary, was at first 5*s.* a chaldron; it was nearly doubled during the French revolutionary war; it was reduced to 6*s.* in 1824; and was abolished altogether in 1831. Favouritism had as much to do with the imposition of duty as public revenue, for Charles II. granted to the Duke of Richmond a toll or duty of 1*s.* per chaldron on all coal shipped in the river Tyne to be consumed in England. This duty remained in force more than a century; and during the last ten years of its continuance the proceeds amounted to so much as 21,000*l.* annually! In 1799 the Treasury agreed to purchase this right from the duke and his heirs for a perpetual annuity of 19,000*l.* a-year; and instead of continuing to pay this every year for ever, they paid its marketable purchase-value, amounting to nearly half a million sterling. Large as this sum seems, yet the country was a gainer by the bargain; for during the period of about thirty years that the government received this duty, instead of the Duke of Richmond, the proceeds exceeded by more than a quarter of a million the sum paid to the duke.

Few persons would have any idea of the numerous charges which affect the price of coals. Between the actual coal-owner and the coal consumer, the former residing (say) at Newcastle and the latter in London, the number of petty charges is surprisingly numerous. Lighthouse-dues, harbour-dues, &c. accumulate rapidly. Mr. Holland gives a list of the charges which a ship-load of coals, containing rather more than a hundred chaldrons, incurs in going from the staiths at Newcastle to London. They consist of coast duty; Tynemouth lighthouse dues; the Low Light dues; Trinity light dues; Tees buoy dues; dues for coast lights, Bridlington pier, Scarborough pier, and Whitby pier; Night office; foy; stamp; town dues on coals; town dues on ship and boat; trimming; cranage on ballast; corporation assessment on ballast; purchasing and heaving ballast; spoutage; keel dues; and pilotage—amounting altogether to about twenty-seven pounds. At and about the year 1830 the expense attending the entry and sale of a load of coals in the Thames at London amounted to more than nine shillings a ton, and was made up of the following extraordinarily numerous items:—Government duty, 6*s.*; orphan duty, 6*d.*; city metage, 4*d.*; additional metage, 4*d.*; deputy meters for wages or hire, a variable sum according to circumstances, but amounting to about 3¾*d.* per chaldron; coal heavers, or whippers, 3*s.* for twenty chaldrons; meter's men, 3*s.* for a like quantity; undertakers, 1*d.* for a similar quantity; coal-market duty, 1*d.*; tonnage duty, 1¾*d.*; Trinity and Nore light dues, ½*d.*; other charges of a minor and miscellaneous character, amounting to about 4½*d.* per chaldron in the whole.

Setting aside the Government arrangements as to duty, and the local charges incident to the traffic, the selling-price of coals is regulated in a remarkable manner by a system of agreement among the coal-owners of the North. The proprietors of the greater part of the collieries in Northumberland and Durham have entered into a mutual agreement under the denomination of the "Limitation of the Vends," which has, with a few interruptions, continued in operation for more than half a century. The object in view is to apportion among the different collieries the quantities to be raised and sold, according to the quality of the coal and the power of raising it, and with reference also to the probable demands of the different markets in the kingdom. In the evidence given before a Committee of the House of Commons in 1830, the following was stated as to the mode in which this object is carried out:—When it is understood by the coal-owners that all the parties interested in the coal-trade on the Tyne and Wear are willing to enter into an arrangement of this nature, a representative is named for each of the collieries; these representatives meet together, and from amongst them choose a committee of nine for the Tyne and seven for the Wear. This being done, the proprietors of the best coals are called upon to name the price at which they intend to sell their coals for the succeeding twelve months; and according to this price the remaining proprietors fix their prices. This being accomplished, each colliery is requested to send in a statement of the different sorts of coal they raise and the powers of the colliery, that is, the quantity that each particular colliery could bring to market if at full work; and upon these statements the Committee, assuming an imaginary basis, fix the relative proportions as to quantity between all the collieries, which proportions are observed, whatever quantity the market may require. The committee then meet once a month, and according to the probable demand of the ensuing month, they issue so much for each colliery, according to the greater or lesser amount of the basis or ratio established for each colliery. For instance, suppose the basis of one colliery is fixed at 30,000, and of another at 20,000, according to the quality of the coals and the power of raising them; if the Committee issue ten per cent. on the basis for any particular month, then one of these collieries will during that month raise 3000, while the other will raise 2000. If the demand during a year is higher than the estimate, the increase is fairly divided among the collieries, according to the basis or ratio fixed for each.

It might seem difficult to conceive how the Committee are to predict the quantity of coal required. But this they do by the selling-price at London (the chief mart). If the price has been raised since the last allotment, the next one is increased; if it has fallen, the allotment is diminished—a principle which is observable in most commercial transactions. It is stipulated in the coal-owners' agreement that no one of the members without leave of the Committee shall sell below the fixed price agreed on, under a penalty of five shillings for every chaldron so sold; and every other mode of evading the regulations is checked in the most sedulous manner.

It was estimated about ten years ago, that the quantity of coals shipped coastwise from port to port in this country amounted to more than seven million tons per annum; while the quantity exported to the colonies and to foreign countries was somewhat over half a million tons. London alone received more than two millions. Thirty years ago it was supposed that the inland land and canal transport amounted to ten million tons. Taking all these points together, and allowing for the immense increase which the last few years have witnessed, it has been estimated by Mr. Taylor, that the annual consumption in this country reaches thirty million tons, besides that which is exported.

Not only are there regulations for determining the selling price of coals in the North, but there are also mutual agreements among the coal-factors of London. Thus, in 1834, it was agreed by the coal-factors, "that whenever a greater number than eighty ships reach market on any one day, the factors shall offer them for sale according to the rotation of entry; and that not more than forty of such ships shall be offered for sale on one market-day, unless the price of best coals be 20*s.* or upwards; and in that case to be at liberty to sell such further number of ships as each factor may think proper, giving to every vessel with the same coals her free and regular turn of sale: by which arrangements the ships will experience little or no detention, and the evil be avoided of pressing for sale at a reduced price a larger quantity of coals than the average demand of the market requires." These regulations have been from time to time modified; and newspaper readers have often an opportunity of remarking, that contests occur between the coal-factors and the corporation of London, as to the efficient management of the traffic in the port of London.

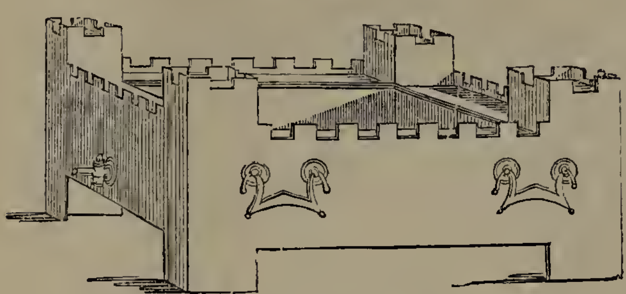
Fireplaces and Stoves.

When we look around us at the domestic mechanism of the fireplace (if such a term may be employed), we find that a singular variety is observable, and that the purity, the economy, and the elegance of the interior of a dwelling are very largely dependent on the mode in which fuel is burned for daily use. It can hardly have escaped the attention of an ordinary reader, that in the narratives of intelligent tourists and travellers, the customary arrangements in these matters, in various countries, go very far to determine many points of individual and national character. So much does habit become part and parcel of the man who is subjected to it, that we often find the inclinations warped in a manner little to be expected. Thus, for example, it has been stated that some years ago, when a large landed proprietor in the north of Scotland was making numerous changes, having for their object the improved condition of the peasantry, he provided more efficient means for burning the turf which forms the common fuel in those parts, so as to avoid the smoke and dirt which resulted from the former mode of proceeding; but the tenants were at first ill-satisfied with the change: the clean white walls and smokeless room gave them an idea of *coldness* and dreariness; and it was some time before they could become reconciled to the change.

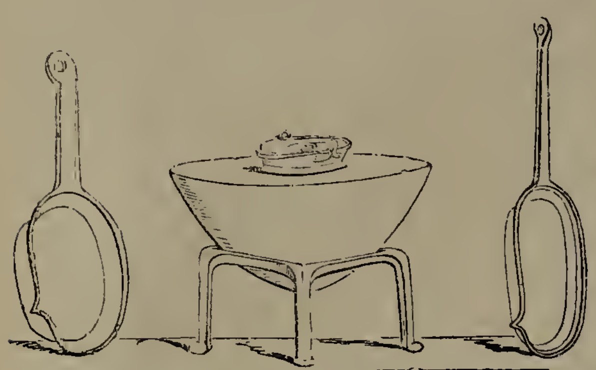
The simple act of procuring heat by the combustion of fuel is only part of the object to be attained. The placing of the burning fuel in such a position as shall avoid danger; the diffusion of the heat throughout a room; the supply of fresh air to maintain the combustion; the means for carrying off the smoke—all have to be, more or less, taken into account in reference to this matter.

Dr. Arnott, who by his writings has done much to draw public attention to what may be called the philosophy of the fireplace, speaks thus of the early stages in the mode of producing a "domestic fireside:"—"The first step made by man in the art of warming himself by fire would naturally be, simply to light a fire in some convenient situation in the open air, and to place himself near it. He would in so doing benefit himself by that portion of the radiant heat which fell on, or was interrupted by, his body; but the rest of the radiant heat, and the whole of the heat combined with the smoke, would be lost or dissipated in the atmosphere. Houseless savages still use fire in this way, as do soldiers in their bivouacs. The second step might be, to light the fire in a place more or less enclosed. Then, not only would the part of the radiant heat which impinged directly on the bodies of persons present be rendered serviceable, but the remainder also, which falling on the walls and warming them, would be partially reflected; and moreover, the heat combined with the smoke would be for a time retained in the place, and would still further warm the

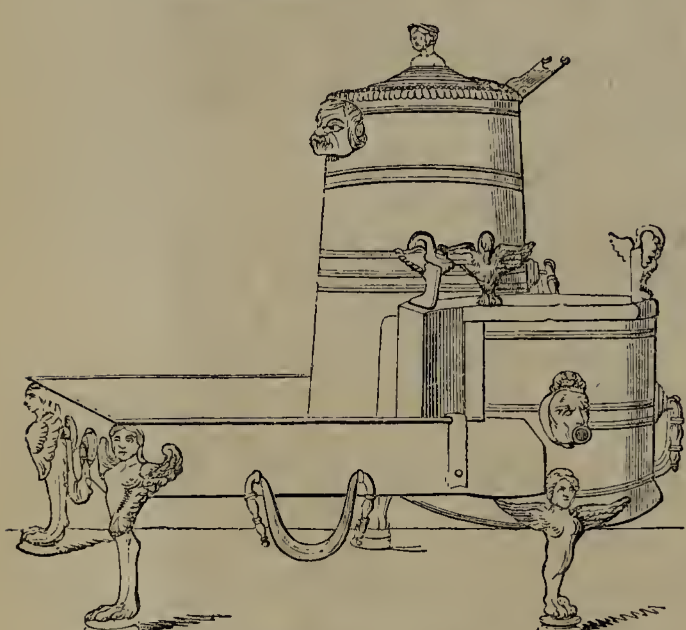
228.—Brazier, found at Pompeii.



229.—Brazier, found at Pompeii.



230.—Cooking-vessels used with the Brazier : Pompeii.



231.—Brazier found at Pompeii.

232.—Stove in Kitchen at Pompeii.

236.—Curfew, Couvre-feu, or Fire-extinguisher.

234.—Fire-place of Old English Cottage.

233.—Anglo-Saxon Kitchen and Fireplace. (From Harleian MSS.)

237.—Remains of a Roman Hypocaust, or Subterranean Furnace, for heating Baths, at Lincoln.

236.—Chimney-Corner in Shakspere's House.

237.—Fire-place and Andirons at Stoke.

240.—Chimney-piece at Kenilworth.

239.—Carved Fire-place in the Palais de Justice, Bruges.

238.—Fire-place and Andirons at Knowle.

242.—Light-producing apparatus.

241.—Boletus igniarius, yielding Amadon, or "German-tinder."

walls and roof, and the bodies of inmates. By such an arrangement nearly the whole of the heat evolved in the combustion is applied to use; but it is conjoined with the smoke or offensive vaporized products of the fuel. The savages of North America thus place fire in the middle of the floor of their huts, and sit around in the smoke, of which the excess escapes by the one opening in the hut, which serves as chimney, window, and door. A few of the peasantry in remote parts of Ireland and Scotland still place their fires in the middle of their floors, and for the escape of the smoke leave only a small opening in the roof, often not directly over the fire. In Italy and Spain almost the only fires seen in sitting-rooms are large dishes of live charcoal, or braziers, placed in the middle, with the inmates sitting around, and having to breathe the noxious carbonic acid gas which ascends from the fire and mixes with the air of the room. There is no chimney; and for the ventilation of the room the only provision is the windows and doors. A closed room with such a fire is, in continental countries, a common means of suicide. The difference between the air from a charcoal fire, and the smoke from a fire of coal or wood, is, that in the latter there are added to the chief ingredients of carbonic acid, others which strongly affect the eyes and nose, and so force attention. Within a few years this barbarous mode of warming was, and I believe still is, used in the halls of some of the inns of court, and of colleges at the old English universities. The third step of advance in the use of fuel probably was to construct over the fire a flue or chimney which should receive all the smoke or offensive aëriferous matters rising from the fire, and by forming of this a long light column of air should cause it to rise with what is called a strong 'draught,' and so depart to mix above with the passing wind. This is the plan now generally used in England."

Countries in different stages of civilization exhibit one or other of these kinds of arrangements, according to the standard of comfort whereby they regulate their wants. The nomade tribes of the desert, whether in Africa, in Arabia, or elsewhere, provide themselves with fire in a way as primitive as they supply all their other wants: the ground is their fire-place, and the sky is their roof; while the fuel employed is any one which may happen to come most readily to hand. The more polished nations of antiquity, however, though deprived of many advantages which we derive from coal, were by no means ignorant of the art of warming their dwellings. A glance at the Roman arrangements will illustrate this.

The Roman *Hypocaust* was a kind of furnace for heating baths. It is known that the Romans employed the hot-bath very copiously; and the arrangements for heating the various apartments, as well as the water itself, were very ingenious. The floors of the baths were made hollow; and from the construction of one found at Pompeii, we may infer as to the general construction. A flooring was first laid down of cement formed from lime and pounded brick. Upon this were built small brick pillars nine inches square by nineteen inches high, supporting strong tiles fifteen inches square. The pavement was laid on these, and encrusted with mosaic. The walls of the bath were made hollow, and communicated with this hollow floor. Upon the walls, solidly stuccoed, large square tiles were fastened by means of iron cramps, the tiles having projecting pieces at the back to keep them out at a certain distance from the wall. The fires, made in some convenient spot connected with the hollow space beneath the floor, sent out heat and smoke which circulated throughout the hollow floor and walls of the building, thereby diffusing a high temperature to the apartment. The remains of an ancient Roman building, discovered some time ago near Lincoln (Fig. 227), evidently belong to this class of hypocausts, or underground furnaces.

Many of the baths were heated in a most complicated manner, showing a nearer approach to the modern methods of warming by heated air than we are generally in the habit of imagining. The methods of heating by hot water and by steam, so far as at present appears, were not known in those times; and indeed the metal pipes then used were scarcely adequate to this object, even if the principle itself had been known. In some of the baths there were numerous rooms, each heated to one particular temperature; and the means for ensuring this degree of heat appear to have been very efficient, to judge from existing remains.

The excavations at Pompeii and Herculaneum have brought to light many examples of the "braziers," or moveable fire-places, used by the Romans; descriptions and representations of which have been given in the volumes on "Pompeii." In the "tepidarium," or warm chamber, of one of the baths, which was kept at a warm but soft temperature, to prepare the bodies of the bathers for the more intense heat of the vapour and hot-water bath, was found a brazier (Fig. 228) seven feet long by two feet six inches broad, made entirely of bronze, with the exception of an iron lining; the two front legs are winged sphinxes, terminating in lion's paws; the two other legs are plain, being intended to stand against the wall. The bottom is formed with bronze bars, on which are laid bricks, supporting pumice-stones, for the reception of charcoal. There is a sort of false battlement worked on the rim, and in the middle of the front a row worked in high relief.

The brazier here described, being intended to heat a large room, is of considerable size; but those for domestic purposes are smaller, and sometimes very elegant; they serve at once to warm the rooms, to keep dishes hot, to boil water, and probably to perform such culinary operations as were of the more simple kind. One such as these (Fig. 229) has hollow sides or walls, intended to contain water; and the four turrets, at the four corners, are provided with moveable lids. From one of the sides there projects a cock to draw off the water. The centre of the brazier was filled with lighted charcoal; and if a trivet or tripod were placed above it, many processes of cooking might be performed. It is believed that some such vessels as those sketched in Fig. 230 were used for this purpose. Some of the specimens are remarkable, and even elegant; such as Fig. 231. This is fourteen inches square, exclusive of a semi-circular projection, which is raised above the rim of the brazier, and made hollow to receive water. On the edge of this stand three eagles, with their heads curving downward toward their breasts, intended probably to support a boiler. A sort of tower rises at the side of this semicircular part, which has a moveable lid, with a bust for the handle.

In the house of Pansa, at Pompeii, was found a curious sort of stove (Fig. 232) used for stews and similar preparations, very similar to the charcoal-stoves employed in some places at the present day. It consists simply of small quadrangular cells for containing the burning fuel; and ledges at the top, on which the cooking vessels might be placed.

It is observable in the present day, that on the Continent the employment of *close* stoves, or those in which the fire itself is scarcely if at all visible while burning, is more general than that of the open English fire-places met with in England. The "Dutch stove" is an example of this mode of construction. This consists of a cylindrical iron case, having within a grating for containing the burning fuel: there is an ash-pit beneath the grating; and in the outer case there is a door or opening at which the fuel enters, another for admitting air and extracting ashes, and a third for the exit of smoke. When a fire is burning within one of these stoves, the heated iron of the outer case warms the air of the room in immediate contact with it, and this warmed air diffuses its temperature among the other air in the room. The arrangement is accompanied by an economy of fuel, and an absence of smoke and dirt; but it has this inconvenience—that the temperature of the heated iron sometimes becomes so high as to decompose the innumerable particles which are always floating in the air; thereby imparting to the air a burnt and sulphureous odour, very deleterious to those who remain long in the room. A vessel of water is sometimes kept near the stove, the evaporation from which gives a little moisture to the too-parched air.

In Russia close stoves are used, analogous to these, in so far as concerns the invisibility of the fire, but on a much larger scale, and capable of more equably diffusing the heat. Porcelain, brick, and earthenware retain heat longer, and diffuse it more slowly, than metal; and hence the Russians have adopted the former class of materials for their stoves, instead of the latter. The stoves are very massive, and often highly ornamental, and consist internally of a series of chambers, through which the heat and smoke pass, so as to impart a warm temperature to a very large mass of brickwork. The authoress of the lively 'Letters from the Baltic' thus speaks of the general arrangement of these stoves:—"Within these great houses not a breath of cold is experienced. The rooms are heated by stoves, frequently ornamental rather than otherwise; being built in tower-like shapes, story over story, of pure white porcelain, in various graceful architectural mouldings; sometimes surmounted with classic figures of great beauty, and opening with brass doors, kept as bright as if they were of gold. In houses of less display these stoves are merely a projection in the walls, coloured and corniced in the same style as the apartment. In adjoining rooms they are generally placed back to back, so that the same fire suffices for both. These are heated but once in the twenty-four hours, by an old Caliban, whose business during the winter it is to do little else. Each stove will hold a heavy armful of billet, which blazes, snaps, and cracks most merrily; and when the ashes have been carefully turned and raked with what is termed an 'ofen gabel,' or stove-fork, so that no unburnt morsel remains, the chimney aperture is closed over the glowing embers, the brass doors firmly shut, and in about six hours after this the stove is at the hottest—indeed it never cools."

From the account which Bell gives of the construction of the stoves in China, they appear to occupy a medium character between the hypocausts of Rome and the close stoves of modern times. Two stove-holes are built in each side-wall of a house, about three feet from the gable end: the holes are a foot square; one serves for receiving the fuel, and the other to let out the smoke. A partition of brick runs from one side of the house to the other, about five or six feet from the gable, and eighteen inches high. Between this and the gable are built several other thin partitions of brick, in a direction at right angles to the first, having a small opening at the extremity of each. These openings are so arranged, at alternate ends of the small partitions, that the smoke and heated air must traverse the sides of all of them from end to end before arriving at the opening by which they escape into the open air. These divisions being made, the whole is arched or covered with brick; above which is laid a layer of clay or plaster, to prevent the smoke from rising through the surface. A few handfuls of brushwood, straw, or any kind of fuel, being introduced into this underground stove, will warm the brick, clay, plaster, or other earthen materials around; and these slow-conducting materials give out warmth enough to gradually warm the apartment above them.

The old traveller Pietro della Valle, who visited Persia in the early part of the seventeenth century, gave a description of Persian arrangements in respect to fireplaces, which, from the recitals of more recent travellers, seems to apply with considerable closeness to the system at present acted on in many Eastern countries. "I noticed," says he, while sojourning at Puli Shah, "one matter which I deem worthy of mention, not as regarding Curdistan alone, but the whole of Persia, even in the most considerable houses. They kindle their fires not under a chimney, as is usual with us in fireplaces, but in a kind of oven called *tinnor*, about two palms from the ground, formed of a vase of burnt clay, in which they place burning coals, charcoal, or other combustible matter, which quickly lights. After this, they place a plank over the oven in shape of a small table, which they cover entirely, spreading over it a large cloth which extends on all sides to the ground, over a part of the floor of the chamber. By this contrivance, the heat being prevented from diffusing itself all at once, it is communicated insensibly and so pleasantly throughout the whole apartment, that it cannot be better compared than to the effect of a stove. Persians at their meals, or in conversation, and some even sleeping, lie on the carpets round this small table, supporting themselves against the walls of the apartment on cushions kept for the purpose, which likewise serve for seats in this country; the tinnor being so placed as to be equally distant from the sides of the room: by this means those to whom the cold is not unpleasant put their legs only under the cloth, others who feel it more sensibly, their hands and the rest of their body; so that a mild and penetrating warmth diffuses itself agreeably over the whole body without any injury to the head, as I have repeatedly experienced. Of the excellence of this contrivance I am so fully persuaded, that I am resolved on adopting it when I shall return to Italy. Those who feel no necessity for additional warmth, or who are sufficiently warmed, by throwing aside the cloth feel no other temperature than that of the apartment itself, which is heated to a pleasant degree. The smoke from the coals is conveyed by means of a pipe from the oven underground; and by means of another communicating with the grated bottom of the fire it is supplied with air." It is known from the accounts of more recent travellers, however, that this is not the *only* kind of stove found in Persia. There is occasionally to be seen an open fireplace bearing some analogy to those of past ages in England.

That the old-fashioned dwellings of this country exhibited the open hearth, within a huge fireplace (Fig. 233), but without anything which can be called a stove or a grate, is known to those who can glance at any of the old pictures of country life. The sketch presented in Fig. 234, though it may be ideal in some of its parts, is full of truth as to the general arrangement of English cottages in times which are long gone by. Such cottages were principally built of wood and clay, with a strange but perhaps picturesque disregard of anything like symmetry of shape. There was a rude door, and an equally rude window; the stairs were a kind of step-ladder; and the ceiling had so many beams and projections as almost to lose its appearance of horizontality. The fireplace was wide and open; and had a hearth, raised a little way from the ground, on which the burning fuel was placed. The smoke found its way partly up the chimney and part into the room; and in this respect the similarity to the open Persian fireplace is sufficiently apparent. Another sketch (Fig. 236), of a chimney-corner in Shakspere's house, has many compeers in old dwellings.

The ancient English custom of using the *curfew* illustrates the kind of fires employed in old times. The curfew is rather a barbarous mutilation of the French "*couvre-feu*," fire-cover, and was the name given to an instrument which acted as a fire-extinguisher. Several years ago Mr. Grose gave a description in the 'Antiquarian Repository,' of an ancient curfew in the possession of the Rev. Mr. Gostling. This instrument (Fig. 235) was made of pieces of

copper riveted together: it was ten inches high, sixteen inches wide, and nine inches deep, and shaped something like the common domestic Dutch oven. The fire which was to be extinguished by this instrument was made on the hearth; and when it was desired to put out this fire, the wood and embers were raked as close as possible to the back of the hearth, and the curfew was put over them, the open part being placed close to the back of the chimney: the air was almost wholly excluded by this means, and the fire soon died away. William the Conqueror made a law that at the ringing of the curfew-bell, at eight o'clock in the evening, all his subjects were to extinguish their fires and retire to rest. Many writers think that this was a sound measure of police, to guard against accidents by fire to the wooden buildings of the period; but Thomson makes it a theme for some indignant lines:—

> "The shiv'ring wretches, at the curfew sound,
> Dejected sank into their sordid beds;
> And through the mournful gloom of ancient times,
> Mused sad, or dreamed of better."

In the houses of the better classes in England in past times, besides the more elegant plan of the fireplace itself, there were certain little conveniences for the management of the fuel, marking a line of distinction between the firesides of the high-born and the humble, the rich and the poor. Such were the *andirons* still seen in some old mansions, and represented in old prints. At Stoke Manor House, for instance, the wide and ample fireplace (Fig. 237) gives an idea of the mode in which the andirons were arranged, and of the side recess where the billets of wood were kept. In Shakspere's 'Cymbeline,' Iachimo, describing the furniture of a room, says:—

> "The roof o' the chamber
> With golden cherubins is fretted: Her *andirons*
> (I had forgot them) were two winking Cupids
> Of silver, each on one foot standing, nicely
> Depending on their brands."

In the 'Pictorial Edition of Shakspere,' the editor remarks, in connexion with this passage:—"We have no doubt that in this description Shakspere literally describes some work of art which he had seen. At Knowle, one of the most interesting of ancient mansions, there are 'andirons,' of which the 'two winking Cupids of silver' are not, indeed, 'each on one foot standing,' but in an attitude sufficiently graceful to show us that such furniture was executed not only of costly materials, but with a skill such as the Florentine artists applied to the ornamental appendages of the palaces of the great." The andirons here described are sketched in Fig. 238.

That fireplaces afford scope for the display of great taste in design, and in the exhibition of elaborate carving, costly painting, &c., is obvious. Many of the fireplaces in the houses of the old English nobility are among the most elaborate features of domestic decorations. There was a celebrated carver, Grinling Gibbons, who, in the reign of Charles II., left memorials of his skill in this way, which still remain to show us that in this branch of art we have not kept pace with past ages.

The fireplace in the Palace of Justice at Bruges (Fig. 239) is one of the most remarkable specimens of carving applied to this object. The present palace was built in 1722, on the site of an old building which had been the palace of the Counts of Flanders, and which had been given up to the magistrates by Philip the Good. Several relics of the old building are preserved in the present Palace of Justice, amongst which is this admirably carved fireplace or chimney-piece, in the room where the magistrates hold their sittings. The bas-reliefs of the frieze are in white marble, and represent the apocryphal story of Susannah; statues in wood represent Charles V. with the globe and sword of justice, Maximilian and Mary of Burgundy, Charles the Bold, and Margaret of England, his third wife; together with escutcheons, containing the arms of Spain, Burgundy, Brabant, Flanders, &c.

The history of this fireplace is said to be rather curious. M. Delapierre, in his 'Album Pittoresque de Bruges,' gives the story, worked up in rather a romantic form, probably from a tradition in the town itself; but the chief points are as follow:—André, the artist of this work, was a carver, who was living in Bruges in 1527, and who had executed a number of works which had brought him considerable reputation. He was a widower, but had a daughter about ten years old, who lived with him, and an old female relative, who was nearly blind and deaf. There was another carver at Bruges, Jacques van de Pitte, who envied and at length hated André, on account of the superior skill and fame of the latter. Jacques tried, by underhand and plausible insinuations, to damage the reputation of André; but the more he tried, the more did his rival seem to rise in public opinion. The Prevôt of St. Donat selected André, in preference to Jacques, to execute a communion-table of exquisite workmanship; and the town of Ypres gave him also the preference in the making of a superb pulpit for the Church of St. Martin. This roused the fury of Jacques to the utmost, and he contemplated a deadly revenge. In a violent scene at the house of André he was the means, indirectly, of causing the death of the old woman; but the circumstances under which the death took place threw suspicion on André himself. He was imprisoned; and his examination having failed to show how the catastrophe really occurred, and his rival, too, having circulated reports tending to excite ungrounded suspicion, poor André was sentenced to death. The prevôt, however, succeeded in procuring the suspension of the sentence for one year, with a view to see whether anything would arise during that period calculated to remove the suspicions against the accused. During this period he was ordered to occupy himself on some work of art in the Palace of Justice, and he resolved that it should be his masterpiece. Day by day he was guided to the hall in the morning, and back to prison at night. He worked with incessant industry, and produced the elaborate chimney-piece still existing. But the excitement proved too much for him: at the expiration of the year his work of art elicited universal admiration, and the magistrates also decided that the evidence against him as an accused man had fallen to the ground; but he died before regaining his liberty. Such is the gist of the tale: even if owing more to romance than to truth, it compliments the work of art itself; for it is only concerning a work of admitted excellence that such a tale would have currency.

The chimney-piece in the gate-house at Kenilworth (Fig. 240) is one among the numerous specimens of carving in this department which our own country can exhibit. But we may now leave this subject, and pass on to take a hasty glance at the

Modes of Warming large Buildings.

In large buildings it is very difficult to bring the mass of air to a moderate temperature by the use of any kind of stove or grate. The modern contrivances for dwelling-apartments have generally for their object the economy of fuel or the prevention of smoke. Thus, Count Rumford, some years ago, suggested the "register-stove;" the object of which was to lessen the chance of smoking by narrowing the entrance or throat of the chimney: this was effected by a plate which could be screwed to vary the size of the aperture; but this arrangement, though generally calculated to attain the purpose in view, involves a very rapid expenditure of fuel, on account of the heat lost in the air which passes so quickly up the chimney, one of the consequences of a good "draught." The variety of open fireplaces is almost endless, as every one knows; and each variety lays claim to some particular merit over its compeers. Within the last few years the close stoves, too, have multiplied exceedingly. Since Dr. Arnott proposed his new arrangement for the slow burning of fuel, there have been "Vesta" stoves, "Clunch" stoves, "Olmstead" stoves, and others without number—all having in view, as a general rule, the avoidance of smoke, the equable diffusion of heat, and the economy of fuel. How far these objects have been attained is still a matter for individual opinion; but the probability is that all these are attempts in the right direction. It is worthy of remark likewise, that the taste of our artificers becomes developed in the fabrication of these articles of domestic furniture, for it cannot be doubted that a great advance has been made in the elegance of the designs within the last dozen years.

But in warming buildings of more spacious dimensions, and in making one fire available for many rooms, a totally different arrangement must be sought. The means whereby this is now attained are three—by *heated air*, by *steam*, and by *hot water*.

The heated-air system involves the employment of a fire, with a range of flues so disposed as to carry the hot air to other rooms. Some of the large factories used to be warmed in the following manner:—Fire was contained in an iron receptacle, and at a certain distance from it, encompassing it on every side, was a brick casing or envelope, so that a body of air existed between it and the fire-box. The fire-box had three openings to the exterior, one to introduce the fuel, one to serve as an ash-pit and air-vent, and one for a chimney. The exterior envelope, too, had two openings, wholly distinct from the others; one to carry off heated air to the various rooms of the building, and another to admit a renewed supply of fresh air. Sometimes churches are warmed in a manner somewhat similar. There is, in the first place, a cast-iron stove, shaped nearly like a bell; and this is enclosed in an outer casing, comprising between the two a mass of air to be warmed. The necessary openings are provided to the two cases; and air-tubes, communicating with the vacant space, convey the hot air into the body of the church.

But this method has been now nearly superseded by the use of steam, or of hot water, a brief notice of which we will borrow from the 'Penny Cyclopædia.'

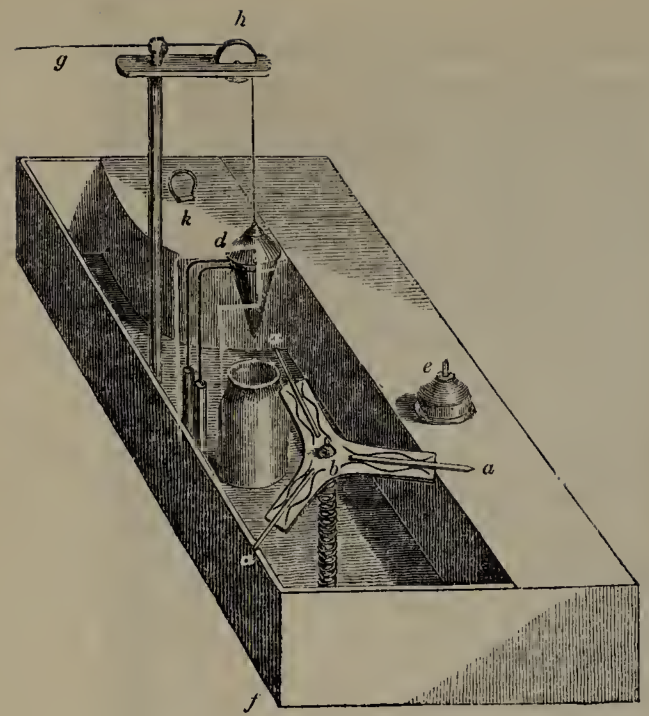
The general arrangements of a steam-heating apparatus, as suggested by Mr. Scott Russell, are nearly as follow. At a convenient part of the building, and as low as possible, is placed a close steam-boiler. From this boiler a small steam-pipe is carried to the part of the building which is to be warmed. This small pipe is pretty thick, and is wrapped round with a bandage of flannel to keep in the heat. Pipes of a larger size are laid round the room above the floor, or under the floor, if apertures be left to allow a free circulation of warmed air to enter the room. Into these larger pipes the steam is conducted, and in them it is condensed into water, giving out its heat to the colder air of the room, which is in contact with the outside of these pipes. Small leaden or tin pipes are provided, for the purpose of bringing back this condensed water into the boiler; for which retrograde movement a gentle slope is given to the pipes; the water thus returned being again heated in the boiler and converted into steam. This mode of heating buildings is adopted to a large extent in the manufacturing districts of the North. In the cotton-mills, flax-mills, power-loom-mills, dye-works, bleach-works, print-works, &c., the facilities for producing an uninterrupted supply of steam are so great, that the steam-heating system becomes by far the most economical that can be employed. In such buildings as these all the rooms and galleries are heated by large steam-pipes, running from room to room, and conveying steam from the same boilers which supply the steam-engines.

The method of warming rooms by hot water has two different varieties, according as it is high-pressure or low-pressure, or according as the boiler containing the water is closed or open at the top; but in both cases the action depends on a peculiar property in heated water. When a vessel of water is heated, the whole mass becomes hot, not by the communication of heat from particle to particle, but by the ascent of heated particles from the bottom up to the top. Heat being applied to the bottom of a vessel, the particles of water near the bottom becoming specifically lighter than before, ascend, while the colder particles at the surface descend to supply their place; and hence a series of ascending and descending currents is formed. Now if, instead of having the heated water only in a vessel, it ramify also through close tubes connected with the vessel, the ascending and descending currents may be passed through different parts of a building, besides the room where the vessel itself may be placed. The heated water, rising to a temperature depending on the fire to which it is exposed, gives out heat to the metal pipe through which it passes, and this pipe again communicates heat to the air of the room. Hence the operation of this method of warming depends on the circulating or ascensive and descensive property of heated water, by which the portion of pipe farthest removed from the fire becomes as much heated as those in its immediate vicinity.

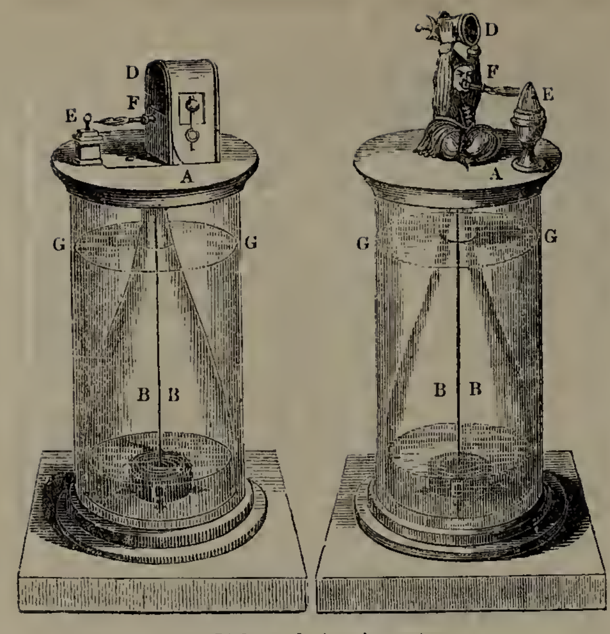
If the object be to warm all the apartments on the same floor as that where the apparatus is placed, an open boiler may be used; but where it is necessary to carry the pipes to different floors of a building, some of them much above the level of the boiler, then the boiler must be closed. When an open boiler is employed, a pipe branches out from the upper part of the side, extends horizontally through the rooms to be warmed (without in any case rising above the level of the water in the boiler), and returns again to the boiler, which it enters at a lower level than that at which it left it. By this arrangement a current of heated water will flow from the boiler at the upper orifice, and, after traversing the tube, return at the lower orifice.

The closed boiler is more frequently used than the open one, since it admits of being applied to all the floors or stories in a building. The whole system, including both tubes and boiler, is filled with water at a valve at the highest point; and when heat is applied to the boiler, a circulation ensues which speedily causes the whole length of tubing to become hot. In this form of the apparatus, the temperature of the water is kept down to a moderate pitch, in order to avoid danger; but in a modification of it, called the "high pressure" method, the boiler consists of a coil of pipe, forming part of the circulating pipe, and is capable of being safely heated to such a degree that the pressure of the water within equals a thousand pounds on the square inch. The whole system of water-circulation is brought to so high a temperature, that the metal of the pipes warms the air of a large building very speedily.

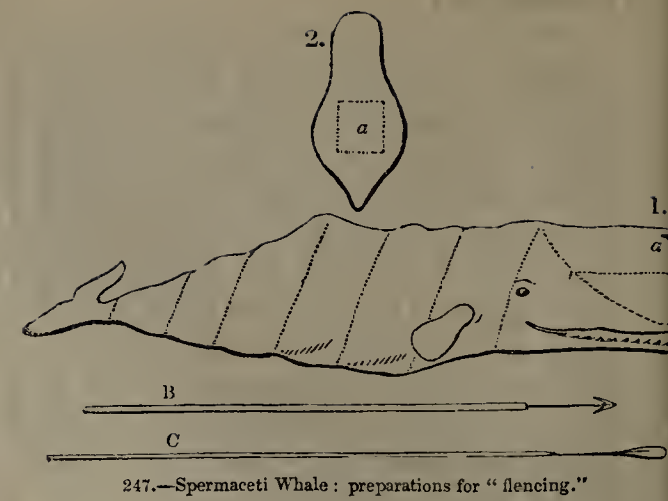
An example of this mode of heating is presented in the reading-room of the British Museum. In the basement of the building is a furnace, with a boiler on the coil-tube principle. Tubes branch out from this boiler, extending to a vacant space immediately under the centre of the room; then turning upwards, they open into horizontal tubing, extending along the middle of the room, directly under the slate pavement of the passage, or central avenue. From this horizontal tubing lateral branches spring, leading to eight pedestals filled with coils of pipe. All the eight coils, as well as the straight tubes, form one unbroken series, through which the heated air from the boiler circulates, imparting its heat to the metal tubes, which in their turn impart it to the air of the room. Among the improvements which Dr. Reid introduced into the House of Commons was that of warming by hot water. Different modifications have been applied, but one of them was thus managed: beneath the house was a vacant space, occupied as an air-chamber; and beneath this again was a basement story in which the apparatus was placed. A warm-water pedestal contained the necessary arrangements for imparting heat to the room in which the pedestal stood. The heated air passed into a passage extending nearly the whole length of the house, and thence ascended through about twenty apertures into



243.—Light-producing Apparatus.

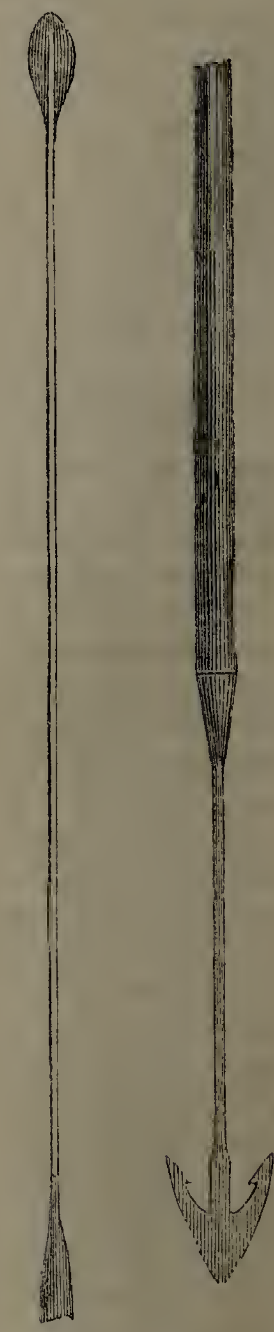


244.—Light-producing Apparatus.



247.—Spermaceti Whale: preparations for "flencing."


246.—Harpooning the Whale in the Arctic Seas, for Lamp-oil.


245.—Whaling Harpoon and Lance.


248.—Virginia Myrtle—yielding Wax.

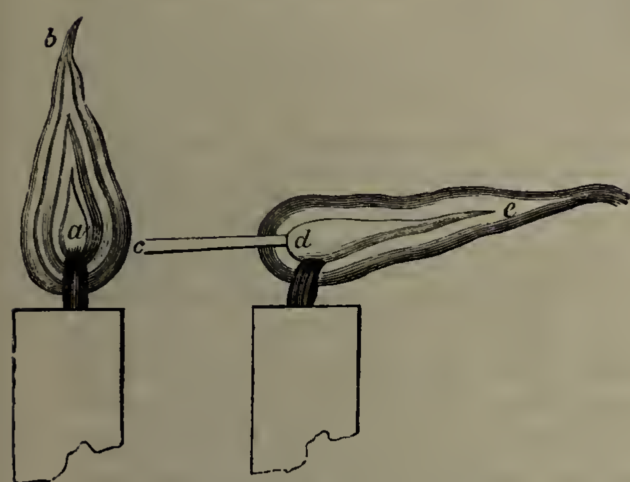

249.—Arachis Nut—yielding West-Indian Oil.


250.—Sesamum—yielding Persian Oil.

254.—Fruit and Blossom of Olive.

253.—Olive-tree in the East.

252.—Carnauba—Corypha cerifera, yielding Brazilian Wax.

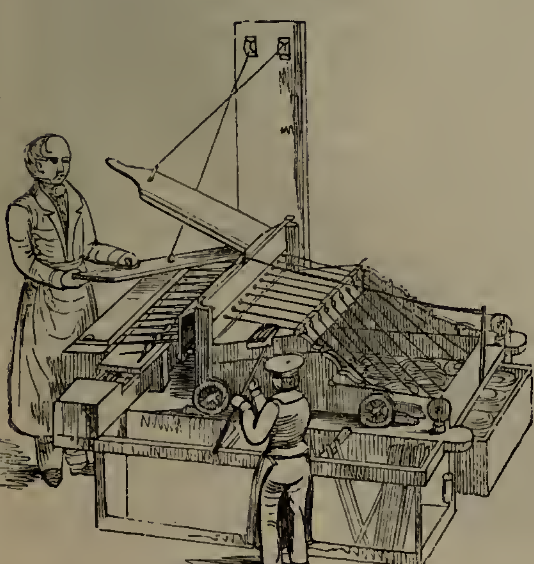


257.—Analysis of the Flame of a Candle.

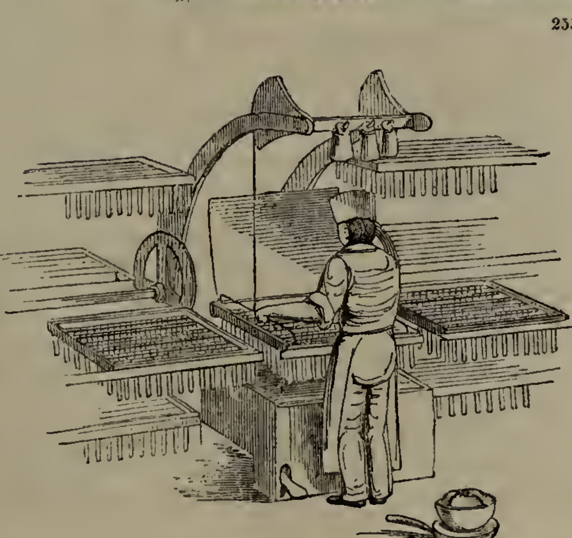
256.—Siphon Lamp.

251.—Elæis Guineensis, and Cocos butyracea, yielding Palm-oil.

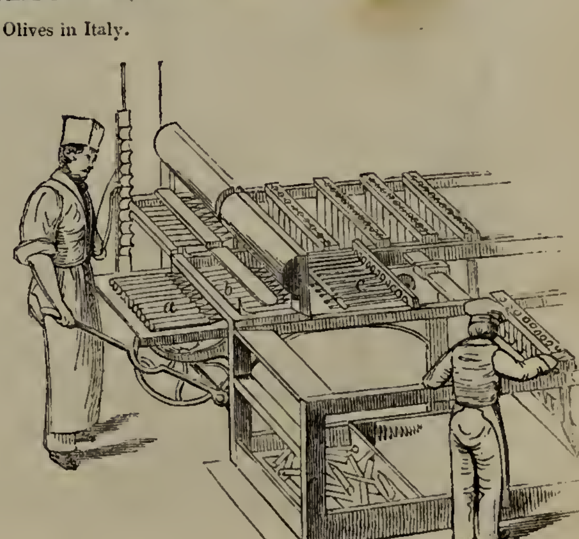
255.—Gathering Olives in Italy.



260.—Candle-making : Machine for cutting the Wicks.



259.—Candle-making : Dipping-machine.



258.—Candle-making : Mould-machine.

the air-chamber, which became filled with warm air. In order that this air might ascend to the body of the house, three hundred thousand holes were drilled in the floor which separated the house from the air-chamber beneath: each hole being about a sixth of an inch in diameter at the top, but expanding to a larger diameter downward.

Thus varied, complicated, and ingenious, then, are the modes which have been devised for diffusing warmth within and about our dwellings.

MEANS OF PRODUCING ARTIFICIAL LIGHT.

The farther northward our observations may be made, the more imperative do we find the need for obtaining some kind of substitute for the welcome and genial sun's light. Within the arctic circle (and equally within the *antarctic*; but we know so little about the southern polar regions, that reference is seldom made to them) there are periods of the year when the sun does not rise at all: at noon-day, if such places *can* have a noon, the sun does not rise above the horizon: his beams, radiated upwards, and then reflected downwards from the clouds, throw a faint twilight on surrounding objects; but broad, clear, and cheerful day is unknown at such a time and place. This state of things occurs for a day or two in winter, in a latitude not very far north of the Orkney Isles; but when a nearer approach is made to the pole, the number of such days is more considerable; and, although we have no records of any human being having actually been at the north pole, it is a fair inference from numerous data that there must in that spot be one long, dreary, unvarying, and unbroken night of nearly six months' duration: the moon *may* shine there a little; the auroræ may possibly lend a welcome ray; but the sun, so far as we can judge, does not show himself unless he has arrived at, or nearly at, a northern declination—when he commences, for the icy pole, an equally long period of unbroken day.

We shall find, from a rapid glance at the usages of different countries, that the means of filling up the sombre interval, necessarily occasioned by the periodical absence of the sun's light, with some kind of substitute, are very varied, and give rise to many departments of art and industry—in some degree associated with those relating to the production of fire; but in others independent of the latter.

Production of Light by Friction.

The question of course arises—how to obtain light in the first instance? How, from the hard, the cold, the lifeless substances which lie around us, to kindle the spark which may become the forerunner to all our arrangements, both for warming and for artificial illumination? Let us see what travellers in the more rude and uncivilized parts of the globe say on this matter.

Le Roy, speaking of the native Americans, says:—"The barbarous nations in the wilds of America have discovered a method of lighting a fire wherever they will: it consists in the friction of a square piece of hard wood against two pieces of softer wood, which are fastened to it. While the two soft pieces are pressed between the knees, the middle hard piece is drilled by the hand with great velocity, so that by the friction a heat is occasioned which shortly causes smoke, and quickly succeeding flame is excited." Again, Father Labat speaks of the Caribbees employing the same means to kindle fire which he had observed among the Kamtschatkadales, viz., thrusting the lower end of a stick into a hole in a board, and whirling it round with great velocity. The Laplanders adopt a similar plan, and when they have once produced a spark, they allow it to fall on the dried bark of the birch-tree. Captain Cook observed a plan nearly identical practised among some of the South Sea Islanders. Captain John Smith, in his account of Virginia, written more than two centuries ago, says:—"Their fire they kindle presently by chafing a dry pointed stick in a hole of a little square piece of wood, that firing itself, will so fire moss, leaves, or any such like dry thing that will quickly burn." Thunberg, speaking of the Hottentots, states:—"When we were encamped in the open air, which was frequently the case, and had forgot to procure fire by means of our guns, the Hottentots made use of another method, which was no less curious than infallible: they took two pieces of hard wood, one of which was cylindrical, and the other flat, with a hole in it; the flat piece was laid down on the ground, and the foot placed on one end of it to keep it fast; after which some dry grass was laid round the hole, and the cylindrical stick being put into the hole, it was twisted round between the hands with such velocity that the friction arising from it set the grass on fire." In the account of a voyage of two Italian missionaries, Angelo and Carli, to Congo, in the latter part of the seventeenth century, the narrator says:—"Some of our men went to gather buckwheat, others to bring wood to make fire. Fra Michael Angelo would have made use of his steel to light; but a black, who was cook, said—'Father, we have no need of that;' and taking a piece of wood about two fingers thick, with many holes in it which did not go quite through, then taking another little stick about the thickness of one's finger, and putting it into one of those holes, rubbed the two sticks hastily one against another with both hands, and the little one took fire, which is their way of lighting it." One more illustration. Sir J. E. Alexander, in his 'Expedition into the Interior of Africa,' says:—"I asked a Boschman to show me how he made fire; when he went and got two small twigs, and with his assegay he squared one twig and made a small hole in it, and gave the other a point; then taking out the bone-barb of one of his arrows, he supplied its place in the reed with the pointed piece of stick, and placing the squared twig between his soles, he commenced rubbing the arrow-shaft between his palms, and pressing the pointed twig against the square one, repeating the anxious cry of 'hei! hei!' till he got a black dust from the two sticks, and, after a quarter of an hour, smoke and a light. At the conclusion of his hard work I drew a lucifer match through sand-paper, produced an instantaneous light, and the Boschman was smote with amazement."

Now in all these cases it is evident that the same principle is observable. In all the quarters of the world, the every-day observations of men have taught them that friction is a source of heat, and that if this heat be developed in a combustible material, a flame may be the result. The differences in the methods are in minor details only; the principle being analogous in all.

A sort of transition to the "flint and steel" of more familiar countries is exhibited in the method practised by the natives of Tierra del Fuego. They rub briskly a piece of pyrites against a flinty stone, and catch the sparks on a dry woody substance. With respect to the action of flint on a piece of steel, it is probable that only a small number of those who employ these little implements are aware of what really takes place. The flint, being a very hard substance, and struck obliquely against a piece of steel, strikes off excessively minute particles of metal; and these particles, heated to a white heat by the sudden percussion, constitute the brilliant sparks which are the first germ of the heat and flame afterwards produced. In the common muskets, and in all analogous instruments, except those where "percussion-caps" are employed, it is the sudden contact of flint and steel that ignites the gunpowder.

The preparation of these flints in war-time constitutes a special and remarkable department of manufacture, of which the following account was given a few years ago in Jameson's 'Edinburgh Journal of Science:'—"Brandon in Suffolk is the head-quarters of the trade. During the war, and before the invention of percussion-caps, when the demand for gun-flints was much greater than it is at present, some were made at Lewisham, Purfleet, Greenhithe, and Northfleet; but at present nearly all the English flints are made at Brandon, where the flint, though not so large in quantity, is of excellent quality for the purpose. The masses of flint from which the gun-flints are made at Brandon, are obtained from a common about a mile south-east of the town. The chalk is within six feet of the surface. The men sink a shaft down about six feet, then proceed about three feet horizontally, and sink another shaft lower down into the chalk; and so they proceed, going sometimes to the depth of about thirty feet. By making their shafts only about six feet in depth they are able to descend, and hand up the stone from one stage to another, without the aid of any machinery; and although a windlass, rope, and bucket might save labour, they would require capital which the poor men who follow this occupation cannot command. They pay a rent of 5*s*. to the parish for every cartload, which is as much as three horses can draw. In the descent of about thirty feet they generally find three floors of flint, and sometimes as many as four. At every floor of flint which they find, they excavate horizontally for several yards, even as far as twenty yards below the chalk. The flint is in large blocks; and the men break these blocks into moderately-sized pieces, so as to be able to hand them up from stage to stage. When engaged in doing this, a man places himself about halfway up between two stages, so as to receive the stone from below, and hand it up to the stage above him. They sometimes sink shafts without meeting with any flint to reward their labours. The masses being thus procured, they are fashioned into gun-flints by the aid of four instruments—an iron hammer with a square head, a steel hammer with a pointed head, a flat circular steel hammer, and a long tapering steel chisel. The workman, seated on the ground, places the piece of flint on his left thigh, and divides it into smaller pieces by blows with the square hammer. Each of these pieces he holds in his left hand, and strikes with the pointed hammer on the edges, so as to produce a series of grooves in the surface; the chips or scales struck out from these grooves being of such size, and cloven in such directions, as to serve afterwards for gun-flints. The mass is broken away piece by piece in this manner; and each of these smaller pieces is separately brought to the wedge-like form which fits them to act as gun-flints.

It can hardly have escaped the notice of any one that a great change has been effected within the last few years in the mode of obtaining light. The flint and steel are fast going into oblivion. It is also observable that every successive stage in the change becomes more and more simple. The "lucifers" and "congreves" of the present day are the most recent examples of those plans in which chemistry, added to mechanical friction, brings about the result. The kind of tinder used in England is sufficiently well known; but on the Continent a substance called *amadou*, or German tinder, is employed: this is prepared from the dried plant of the *Boletus igniarius*, steeped in a strong solution of saltpetre, and cut into thin slices. The plant grows horizontally (Fig. 241) from the sides of the cherry, the ash, and other trees: when it first makes its appearance, it is a little round, wart-like substance, the size of a pea, of a yellow colour, and of a soft yielding texture; it gradually increases in size and hardness till it becomes of a darkish brown, and is as large as an apple; it afterwards takes a horizontal direction, and assumes something of a woody texture.

Some years ago a contrivance was introduced in France for obtaining a light by means of the heat developed in compressed air. A strong tube (Fig. 242) is furnished with a piston, which may be driven rapidly from end to end within it. The upper end of the tube has a number of small holes communicating with a cell or recess containing a little tinder. On forcibly driving up the piston, the air within the tube becomes heated by compression, and a number of minute streams of heated air, rushing through the apertures, ignite the tinder and thus give a light.

The use of some chemical agent has, however, been the kind of method which has led to the most useful results. Phosphorus was one of these agents. A bit of this substance was placed in a small tube or bottle; and when a light was wanted, a match tipped with sulphur was pressed against the phosphorus, so as to detach a minute particle, and then rubbed quickly against a cork, by which the match was kindled. A further method was founded on the fact that a mixture of chlorate of potash with sulphur, camphor, or charcoal, will take fire when placed in contact with sulphuric acid. Matches were tipped with this composition and then dipped into the acid. A very curious piece of apparatus (Fig. 243) was contrived to make this in some degree a self-acting method. In this apparatus three matches are fixed in a metal frame turning upon a vertical axis, around which is wound a bit of string fastened to a spring: the little frame is turned so that one of the matches rests against a wire attached to the conical stopper of the bottle containing the acid. A string, extending to the bed-side or the chair of the person who wishes to obtain a light, passes over a pulley, and is connected with the stopper of the bottle. The string being pulled, the stopper rises, wet at the lower end by the acid in the bottle: the match, pressing against this wetted end, becomes kindled, and is forced by its spring round to a spot where a small spirit-lamp is placed, by which a permanent light is procured.

Another method, equally elaborate with this latter, depends on the fact that, if a stream of hydrogen gas be directed against a bit of platina in a state of minute division, the platina will become red-hot, and the hydrogen gas will become immediately inflamed. There is a cylindrical glass vessel (Fig. 244) almost full of dilute sulphuric acid: within this is a smaller bell-shaped vessel, with its larger end downwards, and suspended in this inner vessel is a coil of zinc. From these elements hydrogen gas is evolved; and this gas, rushing out from a tube at the top of the vessel, kindles a bit of platina against which it is propelled. Sometimes, as in the right hand of the cut, the contrivance for kindling the platina is grotesque, is ornamental, and indeed capable of indefinite variation.

But how complicated are all such contrivances when compared with the simple and marvellously cheap "congreves" of the present day! A little chlorate of potash, or some other chemical agent, applied to the top of a match, and rubbed against a roughened surface, produces a light with less trouble than any other arrangement yet devised. The extent to which the manufacture of these little light-giving implements has extended is enormous. There is one establishment in London where a large and beautiful machine, worked by a steam-engine, is employed solely for cutting up logs of wood into the form of splints or matches for this purpose. A witness, examined a year or two ago before the Parliamentary Commission on the Employment of Children, stated that he used a thousand pounds' worth of American pine yearly in making "lucifer" boxes, of which, he believed, from twelve to fifteen thousand gross were made every week in London; and, as each box contains about fifty matches, the yearly consumption would amount to five thousand millions!

Whale-Oil, for Artificial Light.

We have thus watched the various modes of pro-

curing light from the cold mineral and vegetable substances which are presented to hand; and we have next to see how this momentary light (for momentary it is) is made available for diffusing a cheerful gleam over the otherwise dark apartments towards the approach of night.

Among the various inflammable substances which are used for the purposes of illumination, *oil* has been at all times one of the most plentiful and the most efficacious: and, of all the sources whence this may be obtained, the whale is in every respect the most remarkable. Without stopping to describe the structure or habits of this enormous tenant of the ocean, we may fittingly notice the industrial arrangements whereby the oleaginous portions of the bulky animal are made to yield the material for "feeding the flame" of our lamps.

In the first place, then, it will be well to remark that *spermaceti*, although produced in whales, is a different substance, and is derived from a different part of the body, from oil; and, moreover, that the *sperm*-oil is produced by a different species from that which yields the common oil. The Greenland whale-fishery, for the sake of the oil, whalebone, &c., is the most celebrated, and concerning it we may give a few details.

The whale-ships, which are generally from three to four hundred tons' burthen, commonly leave England in time to reach the Shetland Isles about the beginning of April; they complete their ballast and lay in part of their stock in these islands, and depart so as to get to their fishing-stations in the Greenland seas by the latter end of May. A Greenland ship, besides a master and surgeon, generally carries a crew of forty or fifty men, comprising several classes of officers, such as harpooners, boat-steerers, line-managers, carpenters, coopers, &c. It is commonly provided with six or seven boats, which, as affording the principal means whereby the fishery is to be conducted, are suspended round it in such a manner as to admit of being detached and launched with great expedition. All the operations connected with the attack, capture, and destruction of the whales are carried on in the boats. Each boat is provided with harpoons and lances, such as are sketched in Fig. 245 and in the lower part of Fig. 247. The harpoon is of iron, and is about three feet in length; it consists of a shank with a barbed head, each barb having an inner and smaller barb in a reversed position. The harpoon is attached by the shank to a line or rope of about two inches and a quarter in circumference; each boat is provided with six of these lines, whose united length is more than three-quarters of a mile. The use of this weapon is merely to strike and hook the fish. The lance, which effects his destruction, is a spear about six feet long, consisting principally of a wooden stock or handle, fitted with a very thin and sharp steel head.

The men lower the boats and go out to attack any whales which may be in sight (Fig. 248). When a whale is floating on the water, and can be approached unperceived, the bold harpooner strikes his harpoon directly into the soft covering of the animal's body. Startled by the attack, the whale makes a convulsive effort to escape; and at this time the men are often in great danger, for the boat is subjected to the most violent blows from the head, fins, and tail of the whale—especially the latter, which sometimes sweeps the air with such irresistible force as to threaten destruction both to boat and men. He immediately after this dives down into the depths of the ocean with great velocity, running at the rate of eight or ten miles an hour. The moment that the whale thus disappears a flag is elevated on a staff, and the men watching on board the ship rouse all their comrades, who assist in the subsequent operations. The swiftness with which the line is drawn out by the whale occasions so much friction as it passes over the gunwale of the boat, as frequently to make it smoke; and it is only by pouring water upon the wood that it is prevented from igniting. It also occasionally happens that the whole line in the first boat is run out before another has arrived; and if this occurs, or if anything prevents the free unwinding of the rope, the boat is infallibly pulled under water by the whale, and the men can only escape by throwing themselves into the sea and holding by their oars. Sometimes one or other of the men becomes entangled in the rope, while thus running out with such extraordinary rapidity, and in such instance they are almost cut in two, and are hurled into the water.

After the fish has remained a long while under water, he returns again to the surface, sometimes at a considerable distance from the spot where he descended, and with the harpoon still sticking in him. The scene which then ensues, according to the description of Captain Scoresby, is very exciting:—"Immediately that it reappears, the assisting boats make for the place with their utmost speed; and as they reach it, each harpooner plunges his harpoon into the whale's back, to the amount of three, four, or more, according to the size of the whale and the nature of the situation. Most frequently, however, it descends for a few minutes after receiving the second harpoon, and obliges the other boats to await its return to the surface, before any attack can be made. It is afterwards actively plied with lances, which are thrust into its body, aiming at its vitals. At length, when exhausted by numerous wounds and the loss of blood which flows from the huge animal in copious streams, it indicates the approach of its dissolution by discharging from its blow-holes a mixture of blood along with the air and mucus which it usually expires, and finally jets of blood alone. The sea to a great extent around is dyed with its blood, and the ice, boats, and men are sometimes drenched with the same. Its track is likewise marked by a broad pellicle of oil, which exudes from its wounds and appears on the surface of the sea. Its final capture is sometimes preceded by a convulsive and energetic struggle, in which its tail—reared, whirled, and violently jerked in the air, resounds to the distance of miles. In dying, it turns on its back or on its side; which joyful circumstance is announced by the capturers with the striking of their flags, accompanied with three lively huzzas!"

The capture of a whale is sometimes effected in a quarter of an hour, but sometimes lasts forty or fifty hours. Sometimes, when the harpooners think that their work is nearly achieved, the whale breaks loose, and escapes from them altogether. On one occasion, mentioned by Scoresby, there was a whale which, after being harpooned, escaped with a boat and nearly four miles of rope; at a distance of nine miles the men in the other boat again came up with him; but he espied them, and again darted off; a third time they overtook him, and at length succeeded in killing him with their lances and harpoons, but not without requiring the aid of eight boats, and nearly six miles of line.

All the narrators and historians of the whale-fisheries give examples of the mishaps which occasionally occur. Thus, Scoresby says that on one occasion four boats were dispatched in pursuit of a whale, and two of them succeeded in approaching it so closely that two harpoons were struck at the same moment. The fish descended a few fathoms in the direction of another of the boats, which was in the advance, rose accidentally beneath it, struck it with his head, and threw the boat and men about fifteen feet into the air: the boat was inverted by the stroke, and fell into the water with its keel uppermost. All the people were picked up alive by the fourth boat, which was just at hand, excepting one man, who, having got entangled in the boat, fell beneath it, and was lost. As a second example, we may give one described by Mr. Bennett, in his 'Narrative of a Whaling Voyage:'—"A fifty-barrel whale (alluding to the quantity of oil procured from it), brought to the ships on the 15th of August, was captured in a remarkable manner. The creature had liberated another cachalot by biting asunder the harpoon-line, but in doing so became entangled in the line, and was himself retained by the boat, and killed with the lance, without having been harpooned. This victim to friendship was not destroyed, however, without difficulty and danger. One blow from his flukes took effect upon the head of a boat assisting in his destruction, nearly separated the stem from the planks, and upset her, casting the crew into the sea. The first boat was under the necessity of receiving the crew and apparatus of the wreck; but it fortunately occurred, that during the time occupied in conveying the shattered boat and her crew to the ship, the whale lay motionless on the surface of the water spouting blood; and upon being again attacked by the boats, ran rapidly for a short distance, went into his flurry, and died."

The whale, having been captured, is towed along by the boats, and secured to the side of the ship. The oil, which is the main object of the enterprise, is obtained from the blubber or fat of the animal; and the process of "flencing" has for its object the cutting off of this blubber from the body of the whale. The blubber covers the whole body immediately beneath the external skin; it is of a firm consistence, and of a yellowish colour; it varies from eight to twenty inches in thickness, and seems to consist of an oily matter contained in an assemblage of minute fibrous cells. The under jaw, the lips, and the tongue, are formed almost wholly of this substance. The dead whale being secured by ropes to the side of the ship, some of the men descend upon its body (their shoes being armed with spikes to prevent them from slipping), and firmly attach some hooks to the blubber surrounding the neck. A band of blubber, two or three feet in width, and passing round the animal immediately behind the head, is called the "kent," and to this kent the hooks are attached. The hooks are connected with pulleys attached to the rigging of the ship, and the object is to be able to turn the whale over and over by unwrapping the kent, as it were (like a bandage), from around the animal. The tail is cut off, and conveyed on board; and the men begin to cut off the blubber. They are provided with knives and spades of various kinds, large and small, with which they divide the blubber into oblong "slips;" each slip, as it is cut off, is hauled up by a pulley into the ship, until the whole is removed from that side of the whale which happens to be uppermost. By a powerful movement of tackle the ponderous animal is "kented," or turned over, so as to present another layer or slip of blubber uppermost, which is cut off as before, from head to tail. By successive turnings and cuttings the whale is deprived of the whole of its blubber or fat. This done, and the whalebone and a few other useful parts of the animal being removed, the carcase is turned adrift, and becomes food for sharks and other monsters of the deep.

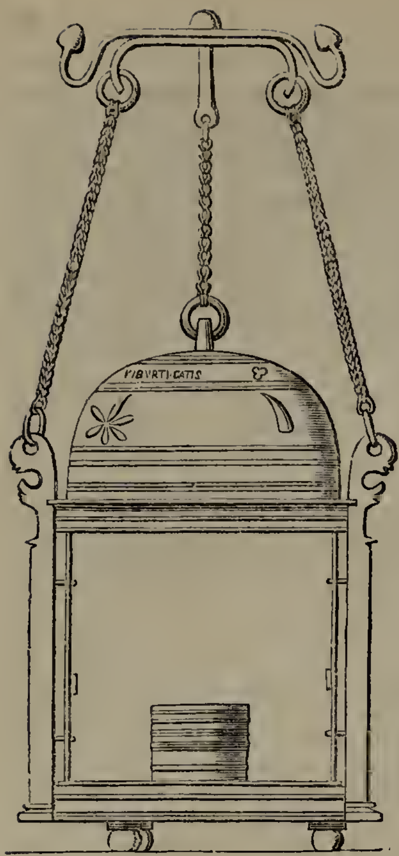
As the various pieces are hauled up into the ship, they are cut up on deck into masses equal to about a cubic foot each. These are passed down between decks, through a hole in the upper one, and ranged in a compact manner, until all the blubber is collected from the whole. The receptacle is gradually filled with the produce of several whales; and when full, the blubber is cleaned and packed up in barrels. To effect this the barrels are ranged all over the lower parts of the vessel, with the open bung-holes uppermost. A kind of trough is placed upon deck, and at the side of this is a table covered with pieces of whale-tail—a substance which has great tenacity and elasticity, and serves as a kind of chopping-block. A hole in the bottom of the trough is connected with a shoot or spout leading down to the casks beneath the deck, through which the pieces may descend to their proper places. From each piece are reclaimed all the muscular and fibrous portions, together with the outer skin; and being so far clean, it is cut up into pieces of sufficiently small diameter to pass into the casks. When each cask is completely filled, it is closed up, and stowed away in the hold. A ground-tier of casks being thus completed, another tier is heaped upon it, until there is a compact mass of filled casks.

The ship, thus laden with her unctuous but not very savoury treasure, wends her way home to Hull or some other port, where the oil is extracted from the blubber. The contents of the casks are emptied into a large wooden cistern, and from thence into a copper boiler, where they are exposed to heat. As the oil is liberated, it flows through a filter of brushwood into coolers, where by a few subsequent operations it is prepared for the market. The bulk of oil obtained is about four-fifths that of the blubber which yields.

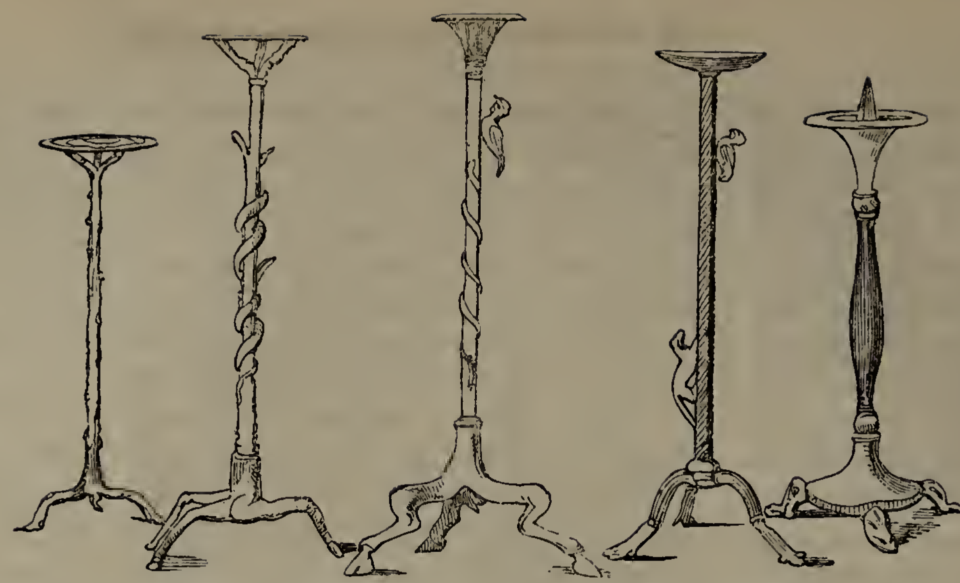
Spermaceti—Seal and Pilchard Oils.

The whale of which we have been speaking is the Greenland whale; but there is a kind captured in the South Seas denominated the *spermaceti* whale, from a peculiar substance which the animal yields. In the upper part of the head of the sperm-whale is a cavity (Fig. 247), called by whalers the "case," lined with a beautiful glistening membrane, and covered by a thick layer of tendons and muscular fibres. This cavity is for the purpose of secreting and containing an oily fluid, which after death concretes into a granulated substance of a yellowish colour, constituting "spermaceti." A large whale will yield, from this remarkable cavity in the head, more than ten large barrels of this substance. Naturalists scarcely seem yet to have arrived at a definite opinion concerning the purpose which this singular secretion is intended to answer in the economy of the animal; but, be it what it may, man has found out that this spermaceti will supply him with inflammable food for his candles and lamps; and the South Sea whale-fishery is conducted in a great measure for the sake of this substance. The blubber is taken from the sperm-whale nearly in the same way as from the Greenland whale; and the oblique lines in Fig. 247 will show the mode in which the huge mass of external fat is marked out for "flencing;" but the collecting of the spermaceti is managed by a separate process. The head of the whale is cut off before the blubber is cut, and allowed to float astern of the ship until the other operations are completed: it is then hoisted upon end, the "case" opened, and the fluid spermaceti drawn from it by means of a bucket and pole, the pole being used to force the bucket down into the "case" to procure the valuable contents. When the spermaceti is brought to England, it is put into hair or woollen bags, and pressed between iron plates in a screw-press until it becomes hard and brittle. It is then broken in pieces and thrown into boiling water, where it melts; and the impurities are separated from it. After being cooled and separated from the water, it is put into fresh water in a large boiler, and a weak potash lye added to it. This process is repeated two or three times, after which the whole is poured into coolers, by which the spermaceti concretes into a white semi-transparent mass. This mass, on being cut into small pieces, presents the flaky appearance which is one of the characteristics of spermaceti as sold.

The *seal* is another animal whose body yields oil valuable for purposes of illumination. We know very little either of the seal or the oil which it yields in this country; but in America, and in the colder countries of the North, the fishing or hunting of the seal is an important and exciting employment. To the inhabitants of some of the colder regions the animal is almost invaluable; thus Langsdorff, speaking of a tribe of islanders off the Russian coast, says:—"The animal forms such an essential article to the subsistence of the Aleutians in a variety of ways, that it may be truly said they would not know how to live without it. Of



262.—Elevation of Bronze Lantern, found at Herculaneum.

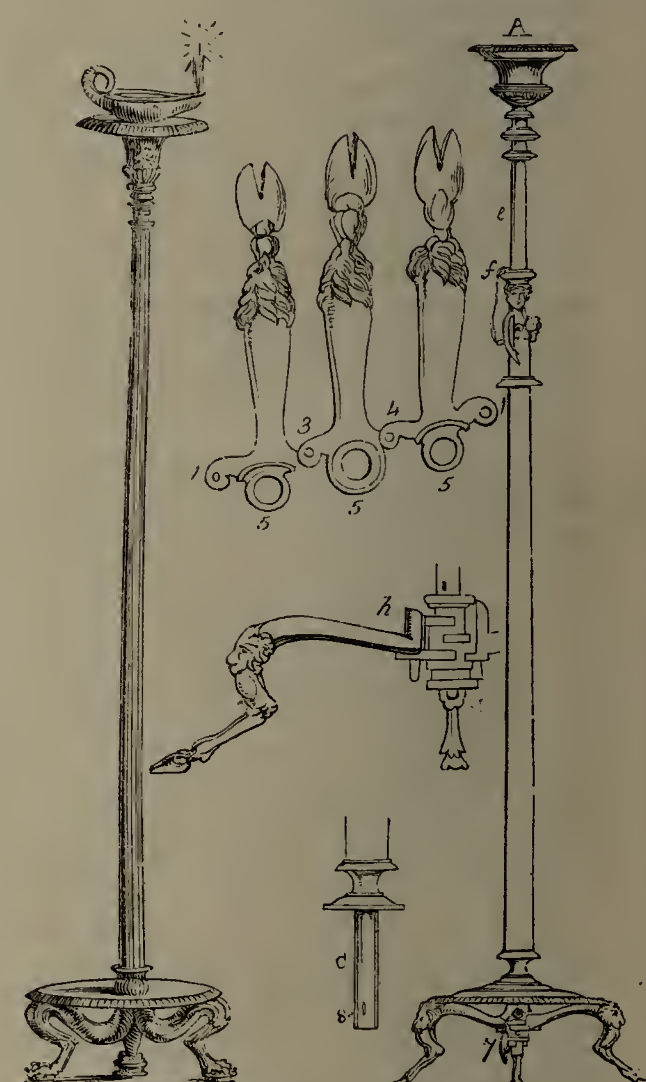


267.—Small Candelabra, from the Townley Collection in the British Museum.

266.—Candelabrum—Townley Collection.

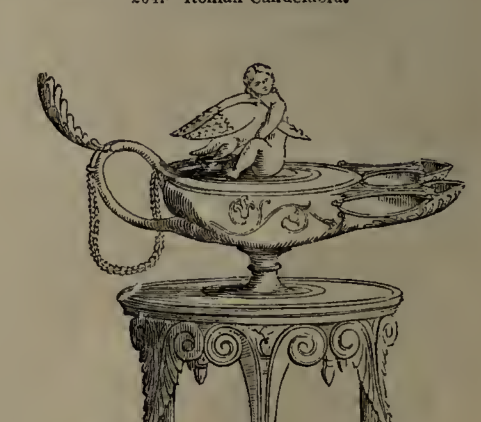
265.—Candelabrum, found at Pompeii.

268.—Marble Candelabrum. (From Piranesi's works.)



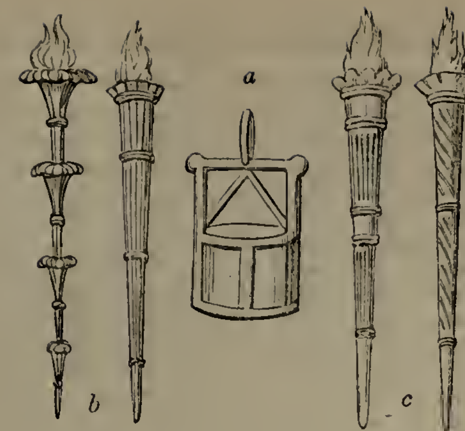
264.—Roman Candelabra.

263.—Section of Bronze Lantern, found at Herculaneum.



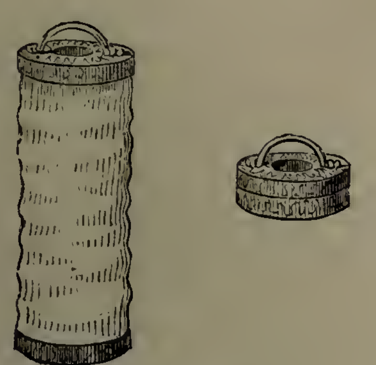
261.—Bronze Lamp and Stand, found at Pompeii.

270.—Flambeaux, from ancient Gems.



271.—Roman Lantern and Flambeaux.

277.—Egyptian Lantern.



272.—Persian Lantern.

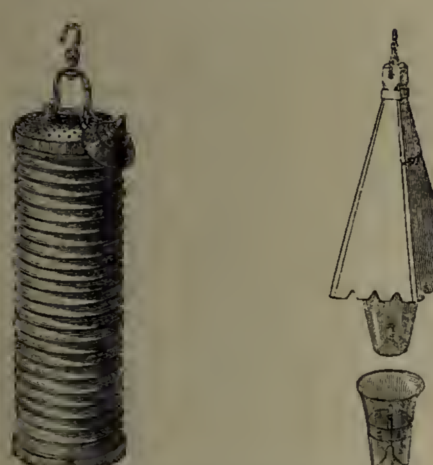
280.—Watchmen's Lanterns, 1616.

279.—Chinese Lanterns.

274.—Persian Torch.

275.—Arabian Torch-Cresset.

273.—Persian Torch and Lantern.



276.—Egyptian Lantern and Lamp.

278.—Egyptian Cressets.

269.—Egyptian Lamps.

its skin they make clothes, carpets, thongs, shoes, and many household utensils; nay, even their canoes are made of a wooden skeleton with the skin of the sea-dog (the common seal) stretched over it. The flesh is eaten, and of the fat an oil is made, which, besides being used as an article of nourishment, serves to warm and light their huts. The œsophagus is used for making breeches and boots, and the large blown-up paunch serves as a vessel for storing up liquors of all kinds. Of the entrails are made garments to defend them against rain, and they also serve instead of glass to admit light into their habitations. The bristles of the beard are used, like ostrich-feathers in Europe, as ornaments for the head. There is, consequently, no part of the animal that is not turned to some use."

The inhabitants of the Orkneys and Shetland hunt largely for seals. Mr. Low, in an account which he gave of the natural history of those islands about the end of the last century, says that at that time a ship went annually to the spots where the seals were found, and seldom returned with less than two or three hundred of these animals. She was manned with between thirty and forty men, who, as soon as they arrived at any rock where seals were to be seen, landed, and immediately surrounded the animals. One party, armed with clubs, commenced knocking them on the head; while another party employed themselves in "jacking," that is, cutting off the skin with the blubber on it; while a third party put the produce on board. They continued this course as long as any seals remained; and when their task was accomplished, they hastened on board and set sail. When they returned home, the "jacks" were divided and sold by public auction, bringing about five or six shillings each; and each man generally got about thirty shillings for his share, after allowing a third for the vessel, and something more than a common share for the master. When the "jacks" were sold, the blubber was cut from the skin and boiled down into oil, which sold well. The skins were fastened to the walls of the houses till dry, and were then sold to the trunk-makers and others for various purposes.

Without enumerating all the varieties of fish which yield oil fitted for illumination, it will suffice to mention the *pilchard*. This fish bears a good deal of resemblance to the herring, but is of larger size, being from nine to eleven inches in length, and much more abundantly supplied with oleaginous matter. The fishery takes place mainly off the coasts of Cornwall; and when the fish are brought on shore, preparations are made for obtaining the oil from them. They are taken to cellars or storehouses, where they are salted and ranged in heaps, from five to six feet in height by ten or twelve in width. After remaining in this state for five or six days, they are packed in hogsheads. By the application of a powerful lever at the top of the hogshead, the oil is extracted, and runs out of the casks through holes made for the purpose: this pressure continues for about a fortnight. The refuse salt, mixed with the scales and blood of the fish, is sold as manure to the farmers, and is applied with great advantage to the land. It is computed that forty-eight hogsheads of pilchards will yield two hundred and fifty-two gallons of oil; and that a hogshead contains about three thousand of the fish.

We might very naturally assume, that as *gas* has now so greatly superseded oil in many of the places where the latter was formerly used, the employment of fish-oil for illumination must necessarily have much diminished; but from the statement by Mr. Porter, in his 'Progress of the Nation,' we find that such would be a hasty inference. He remarks:—"It appears worthy of remark, that notwithstanding the large consumption of coal for gas, which has in a great degree superseded the use of oil for street-lighting, the aggregate consumption of whale-oil has very materially increased. This fact is of course referable to the fashion now become very general of having table-lamps in the place of candles in our dwellings; but it must excite surprise in the mind of every one when first made acquainted with the fact, that during this time the use of candles in dwellings, and especially of wax-candles, has also increased in a greater proportion than the population. It has been suggested, and with much apparent reason, that this increase may be consequent upon the greater brilliancy of the streets since they have been lighted with gas, since we have thus been made dissatisfied with the quantum of light previously thought sufficient within our houses. Certain it is, that our apartments are much more brilliantly lighted now than they were before the introduction of coal-gas, whether that invention be chargeable with the increase or not." This is a very curious point: that *all* the modes of illuminating our dwellings should have progressed simultaneously could hardly have been expected, and seems to indicate one of the items in the general scheme of social improvement.

Oil and Wax produced from Plants.

Many countries are not so circumstanced as to be able to obtain conveniently these varieties of animal oils; but are at the same time in a condition to derive some kind of oil or wax, fitted for purposes of illumination, from numerous plants which are calculated to yield this produce. In nearly all climates there are some or other such plants. The *myrtle*, the *palm-oil* plant, the *arachis*, the *sesamum*, the *carnauba*, and the *olive* (Figs. 248 to 255) are among this number.

The *Virginia myrtle* (Fig. 248) yields a kind of wax, which, when made into candles, burns with a peculiar clear white flame, and gives a beautiful light without much smoke. At the proper season of the year the berries are collected from this plant and boiled in water. The wax contained in the berries rises to the surface of the water, and is carefully skimmed off and strained through a cloth. When no more wax appears the exhausted berries are withdrawn from the water, fresh ones are added, and they in their turn are deprived of the wax contained in them. The wax thus obtained is placed on a piece of linen cloth to be drained, and entirely separated from that portion of water which had been unavoidably removed with it. When dry it soon assumes the consistence of wax, and appears of a dirty green colour. It is then clarified and moulded into cakes, which are nearly transparent.

The *arachis* (Fig. 249), or ground-nut of the West Indies, is now cultivated in France for the sake of the oil which its seeds contain. This oil is very abundant in quantity, and is said by some writers to be quite equal to that of the olive for all culinary purposes, and superior for illumination.

The *sesamum* (Fig. 250), like the arachis, yields oil abundantly from its seeds. This plant is indigenous in the East, and is cultivated largely throughout Asia and Africa, where the seed is highly valued for the uses which it renders. The seeds are about the size of mustard-seed, and the oil is readily expressed from them. Nine pounds of seed yield two quarts of oil, which is used for a great variety of purposes besides that of illumination. The Indians distinguish between two kinds of seed: the one *saffed til*, or white seed, and the other *kala til*, or black seed, yielding oil differing somewhat in quality.

Two plants (Fig. 251), called botanically the *cocos butyracea* and the *elæis guineensis*, yield the valuable *palm-oil* of commerce, the oil being derived from the fruit. It is from the former of these that the supply is chiefly obtained. Of the latter the fruit is about the size of a pigeon's egg, with its outer fleshy covering of a golden yellow colour. The oil is obtained by bruising this fleshy part of the fruit, and subjecting the bruised paste to boiling water in wooden mortars; an oil of an orange-yellow colour separates, which concretes when cool to the consistence of butter, and has when fresh the smell of violets.

The *carnauba* (Fig. 252) is another of the plants producing these useful substances. So likewise is the *tallow-tree*, which grows luxuriantly in China. Of this tree Abel says, "We often saw it imitating the oak in the height of its stem and the spread of its branches. Its foliage has the green and lustre of the laurel. Its small flowers, of a yellow colour, are borne at the ends of its terminal branches. Clusters of dark-coloured seed-vessels succeed them in autumn; and when matured, burst asunder and disclose seeds of a delicate whiteness." The seeds are hard brownish husks, and contain kernels which yield not only oil fit for lamps, but a kind of tallow suitable for making candles. The Chinese subject the fruit to a species of pounding, and then throw the fragments into water, which is heated in a large iron vessel over a fire; the thick consistent mass produced by this means is poured into a kind of barrel or case, and pressed down with the feet as closely as possible. It is then carried to the press, where all the oil is forced out. The tallow is previously picked off the kernels by hand.

The *olive* (Figs. 253, 254, 255), is one of the most valuable of plants in respect to its oil. The wild olive is found indigenous in many parts of the old Continent; and the cultivated kinds are largely grown in Italy, France, and other European countries. The olive grows very readily: in illustration of which, Mr. Jackson, in his 'Account of the Empire of Morocco,' mentions the following incident. He was struck with the whimsical arrangement of a large olive plantation, and inquired the cause of its being so arranged. "I learned," says he, "from the viceroy's aide-de-camp, who attended me, that one of the kings of the dynasty of Jaddia, being on his journey to Soudan, encamped here with his army,; that the pegs with which the cavalry picketed their horses were cut from the olive-trees in the neighbourhood; and these pegs being left in the ground on account of some sudden cause of the departure of the army, the olive-trees in question sprung up from them. I confess, while I acknowledged the ingenuity of the idea—for the disposition of the trees exactly resembled the arrangement of cavalry in an encampment—I treated it as fabulous. Some time afterwards, however, the following circumstances occurred, which induced me to think the story was not only plausible, but very credible. Having occasion to send for some plants for a garden which I had at Agadeer in Santa Cruz, the foulah (gardener) brought, amongst other things, a few bits of wood without any roots or leaf, about eighteen inches long and three in circumference, which he with a large stone knocked into the ground. Seeing the fellow thus employed, I asked him what he meant by trifling in that way? 'I am not trifling,' said he, 'but planting your pomegranate trees.' I began to take them out of the ground; but some persons who were near assuring me that it was the mode in which they were always planted, and that they would (with the blessing of God) take root and shoot forth leaves next year, I was at length prevailed on to leave a few in the ground merely for experiment; and they certainly did take root, and were in a fair way of becoming good trees when I left Santa Cruz."

The olive does not ripen sufficiently to yield its oil in abundance, except in tolerably warm climates; hence the northern part of France does not present olive plantations, whereas the southern, as well as all the countries bordering on the Mediterranean, exhibit them in large numbers. The proper time for gathering olives for the press is just when they approach maturity. In some districts the olive-harvest is annual, whereas in others it takes place only in alternate years. The method of gathering the olives differs in different places. In Portugal, the general way is to beat them down with long poles, and afterwards collect them in sacks or baskets; but the fall bruises the olives, and both fruit and oil are rendered of inferior quality by this mode. The Spaniards gather them all by hand; and though the process is more laborious and more expensive, ample compensation is made in the superiority of these olives over those beaten down by poles.

The olives in the best arranged plantations are spread out for two or three days in beds three inches deep, to allow the water to evaporate before the olives are picked. The fruit is reduced to a pulp, put into sacks of coarse linen, and subjected to pressure. Tho oil first expressed is the purest, and that of inferior quality is the residue.

Candles.

Such, then, are some of the principal modes in which the inflammable ingredients for supplying lamps and candles are obtained; and we may next glance at the ingenious contrivances by which man has been able to bring them into available form.

The object in view is to obtain *flame*, which shall continue uninterruptedly as long as the light-giving agent is present. It is not at first very easy to see how the *solid* substance of a candle and the *liquid* food of a lamp should both lead to the same end, nor how the filaments of cotton which act as a wick contribute to the desired result. It will he well, first, to study the fragment of philosophy which the burning of a candle involves. The wick is composed of a dozen or from that to a score of fibres of soft cotton, ranged side by side, and so far twisted as just to enable them to cling together, but not so close as to prevent the slow passage of liquid between them. When the candle is lighted the heat melts the upper part of the tallow, which then assumes the state of oil: this oil ascends between the fibres of the wick, by the same sort of capillary attraction which will cause a piece of loaf sugar to become wet throughout when placed on a damp spot. These little ascending streams of oil supply minute filaments of combustible matter as fast as the oxygen of the air will consume it in the form of flame. The object of the wick is not itself to burn, for the burning of the wick is a disadvantage, the avoidance of which would save a great deal of trouble; the wick might be made of metal, or any other incombustible substance, provided it presented minute passages up which the liquid tallow might ascend. The particular way in which the oxygen of the air aids the combustion of the candle, renders it necessary that the melted tallow should be divided into minute streams, and this is effected by the peculiar formation of the wick. It may be shown by some such contrivance as Fig. 256, that if oil be contained in a vessel, and a siphon or bent tube be rested on the edge, *b*, in such a way that the higher open end, *a*, dips into the vessel, and the lower open end, *c*, turns upward in the open air, the oil, if the tube be of very small bore, may be kindled at the outer end without the intervention.

As to the nature of flame itself, the action of the blow-pipe on flame gives a little instructive explanation (Fig. 257). If a burning lamp or candle be carefully observed, it will be found that the flame is divided into four parts, which may readily be distinguished from each other. On the lower extremity of the flame, where it is in contact with the wick, will be seen a blue portion, *c*, at the widest part of the flame; the next is the bright intensely-luminous portion, *b*, which surmounts the blue portion in the form of a cone; within this is a smaller cone *a*, of a dark colour, and rising from the upper extremity of the wick; and exterior to all is a thin coating of a slightly luminous flame, *c b*, which forms the continuation of the blue ring. These four portions have different degrees of heat; and by the employment of a blow-pipe, forcibly propelling the flame, as shown in the right hand of the figure, different parts of this flame may be made available according to the object in view. The *hottest* parts of flame are not those which are *brightest*; the blue portion is that which is most highly heated, and by the action of the

blow-pipe is blown into the form *d e*, with its focus at *e*, so that in chemical analysis by the blow-pipe the object to be fused or softened is held in the flame near this intensely-heated spot.

Candles are formed of any kind of solid oleaginous matter, of which the principal are wax, spermaceti, tallow, and palm-oil (the latter being solid in our climate). In using the first of these forms of material, the wicks when cut and twisted are suspended over a vessel containing melted wax, and are coated with this liquid poured on them from a ladle. The wax, flowing downwards, adheres to the wicks; and this is repeated until a sufficient body of wax is laid on. When cooled, the candles thus made are rolled upon a smooth table, to give them a cylindrical form and a smooth surface.

But candles made of tallow are those possessing the most commercial importance. When we find that more than *a million cwts.* of tallow are imported into this country yearly, chiefly for making candles and soap, we may form a rough idea of the importance of the matter. The tallow is derived from cattle, reared almost wholly for this purpose in many of the thinly populated parts of the Russian empire.

The making of the wicks is the first point in the manufacture of candles, and is rather a curious matter. Balls of cotton, spun expressly for this purpose at Manchester, and weighing about three pounds each, are unwound, and several threads are laid together so as to form a wick, the number depending on the size of the candle. This used formerly to be done by hand; but an ingenious machine (Fig. 260) now effects the object. Several of the cotton-balls being placed in a box or drawer of the machine, a man takes the ends of all the threads, doubles a portion of each end round a stick, and by a sharp blade cuts all the cottons to the proper length for wicks; giving to the whole of them, by the action of the machine, a slight twist before he removes them.

These wicks are "dipped" into melted tallow in order to produce the candles, with which every one is familiar. A man takes three sticks, each containing as many wicks as will suffice for two pounds of candles, and dips them into a vessel containing melted tallow; then three others in a similar way; and so on until a large number are done, each stick being hung up after the dipping. When dry, a second dipping is given to them; and so on for a third, a fourth, a fifth, &c., according to the diameter required to be given to the candles. Sometimes the labour of the dipper is lightened by the use of a machine (Fig. 259), in which he is surrounded by candles in a curious way. There are first about twenty candles hanging on a "broach" or stick; then thirty of these broaches are ranged side by side to form an assemblage called a "frame;" then thirty-six of these frames are attached to a machine in such a manner that they may, one after the other, be brought over the vessel of melted tallow. One man and an assistant can make thirty thousand candles in a day by these means.

The kind of candles called "moulds" are made in a different manner. The wicks are stretched down the middle of cylindrical moulds made of pewter, and the melted tallow is poured into the mould in such a way as to be liberated from them when cold. A very ingenious machine (Fig. 258) has been introduced for effecting this operation rapidly. By turning a handle the melted tallow flows out of a receptacle into a number of moulds placed in a row, and when this is hardened by a highly curious action of the machine, the candles, *a*, are pushed out of the mould *b*, by a series of rods *c*.

The Rev. Gilbert White, who allowed nothing to escape his discerning eye which might illustrate the usefulness of natural products, begins one of his letters on the 'Natural History of Selborne' thus:—"I shall make no apology for troubling you with the detail of a very simple piece of domestic economy, being satisfied that you think nothing beneath your attention that tends to utility: the matter alluded to is the use of rushes instead of candles, which I am well aware prevails in many districts besides this; but as I know there are counties also where it does not obtain, and as I have considered the subject with some degree of exactness, I shall proceed in my humble story, and leave you to judge of the expediency." The method is then described. A kind of rush is selected which is found in most moist pastures, by the sides of streams, and under hedges. The largest and longest of them are gathered in summer or autumn, and are placed in water as soon as cut. They are then taken one at a time, and divested of their peel or rind, so as to leave one regular, narrow, even rib from top to bottom, that may support the pith. Thus prepared, they are laid out on the grass to bleach, and are afterwards dried in the sun. These are to form the wicks of candles, of which the coating is to consist of any tallow, skimmings, or fat, which the domestic arrangements of country-people may place at their disposal. It may be that the changes which have taken place since Mr. White wrote render his remarks no longer applicable; but speaking of things at that time he says:—"In a pound of dry rushes avoirdupois, which I caused to be weighed and numbered, we found upwards of one thousand six hundred individuals. Now suppose each of these burns, one with another, only half an hour, then, a poor man will purchase eight hundred hours of light, a time exceeding sixty-three entire days, for 3*s*. According to this account each rush, before dipping, costs one-thirty-third of a farthing, and one-eleventh afterwards. Thus a poor family will enjoy five hours and a half of comfortable light for a farthing. An experienced old housekeeper assures me that one pound and a half of rushes completely supplies his family the year round, since country-people burn no candle in the long days, because they rise and go to bed by daylight. Little farmers use rushes much in the short days, both morning and evening, in the dairy and kitchen; but the very poor, who are always the worst economists, and therefore must continue very poor, buy a halfpenny candle every evening, which in their blowing, open rooms, does not burn much more than two hours. Thus have they only two hours' light for their money instead of eleven."

Ancient Candelabra, Lamps, Lanterns, and Flambeaux.

The employment of solid tallow as a source of artificial illumination is subject to this peculiarity—that it is scarcely available, if at all, in warm climates. Tallow, like butter, is hardly known in the tropical regions; and hence we find that lamps, for the combustion of liquid oil, are, and have been from very early ages, the customary instruments for lighting the apartments of buildings. A candlestick, therefore, in the sense in which we usually apply the term, is scarcely to be looked for in the East.

The excavations at Pompeii and Herculaneum, so rich in results pertaining to almost every branch of art, have not failed to bring to light many elegant specimens bearing upon this department of domestic ornament. Many of the Roman lamps were exceedingly beautiful; witness that one sketched (Fig. 261), which might not unaptly furnish a hint to modern designers.

Both the lamps and the lamp-stands were objects of much attention among the Romans. Winckelmann remarks:—"I place among the most curious utensils found at Herculaneum the lamps, in which the ancients sought to display elegance and even magnificence. Lamps of every sort will be found in the Museum at Portici, both in clay and bronze, but especially the latter; and as the ornaments of the ancients have generally some reference to some particular things, we often meet with rather remarkable subjects." Some of the designs were curious. One specimen met with represents a Silenus, having a face beaming with the joyous hilarity ascribed to this god, and an owl sitting upon his head between two huge beams which support stands for lamps. Another is a flower-stalk growing out of a circular plinth, with snail-shells hanging from it by small chains, which hold the oil and wick. A third exhibits a trunk of a tree with lamps suspended from the branches. Another is a beautifully-wrought representation of a boy, with a lamp hanging from one hand, and an instrument for trimming it from the other, the lamp itself representing a theatrical mask; beside him is a twisted column surmounted by the head of a Faun or Bacchanal, which has a lid in its crown, and seems intended as a reservoir of oil: the boy and pillar are both placed on a square plateau raised upon lion's claws.

The wicks of these lamps were simply a few twisted threads drawn through a hole in the upper surface of the oil-vessel, and there was nothing analogous to the modern "lamp glass;" but the Romans were not ignorant of the convenience and arrangement of lanterns. Thus a very elegant lantern was found at Herculaneum, in 1760, of which Fig. 262 shows the exterior, and Fig. 263 a section of the interior. It is of cylindrical form, with a hemispherical top, and is made of sheet-copper, except the two main supports, which are cast. The bottom consists of a flat circular copper plate, supported by three balls, and turned up all round the rim, from which rise the rectangular supports which bear the upper part of the lantern-frame. The top and bottom are further connected by interior upright pieces, which help to retain the laminæ of horn, or glass, or bladder, which form the semi-transparent case of the lantern. In the centre is seen the small lamp. The hemispherical cover is capable of being lifted on and off, and is pierced with holes for the admission of air.

The candelabra of the Romans bore the same relation to the lamps that our candlesticks do to candles: they simply acted as supports, and were independent of the lamps themselves. "They," says the author of 'Pompeii,' "in their original and simple form, were probably mere reeds or straight sticks, fixed upon a foot by peasants, to raise their light to a convenient height; at least such a theory of their origin is agreeable to what we are told of the rustic manners of the early Romans; and it is in some degree countenanced by the fashion in which many of the ancient candelabra are made. Sometimes the stem is represented as throwing out buds; sometimes it is a stick, the side-branches of which have been roughly lopped, leaving projections where they grew. Sometimes it is in the likeness of a reed or cane, the stalk being divided into joints. Most of those which have been found in the buried cities are of bronze; some few of iron: in their general plan and appearance there is a great resemblance, though the details of the ornaments admit of infinite variety. All stand on three feet, usually griffin's or lion's claws, which support a light shaft, plain or fluted according to the fancy of the maker. The whole supports either a plinth large enough for a lamp to stand on, or a socket to receive a wax candle, which the Romans used sometimes instead of oil in lighting their rooms. Some of them have a sliding shaft, like that of a music-stand, by which the light may be raised or lowered at pleasure."

Fig. 264 represents two candelabra, of which that at the left is very simple, and needs no description. The other one deserves notice for the ingenious way in which the stand or foot is constructed. This stand is formed of three goat's legs, each having a ring at the end and a ring on each side. Above are shown a horizontal and a vertical section of the mode in which these legs are attached to the stem or shaft of the candelabrum; from which it will be seen that they are hinged in such a manner as to be either spread out triangularly, so as to support the stem when in use, or to be folded around compactly side by side when not in use. The stem is square and hollow, terminated by two busts placed back to back, and surmounted with a kind of capital. Within this a smaller stem slides up and down, and is adjusted at the desired height by a pin. The lower stem itself is fastened into the base or stand by a rod which passes into a socket, and is there kept tight by a pin—as sketched on a somewhat larger scale in the lowest of the three small figures. In Fig. 264 A is the stand where the lamp is placed; *e*, the sliding tube; *f*, the place for fastening it; 7, the place where the shaft is fitted to the leg; *c* and *h* (in the smaller figures) parts of the apparatus; and 1, 3, 4, 5, the hinges round which the three legs are adjusted.

Another of these long-buried candelabra, of very elegant design, is seen in Fig. 265. The stem is formed of a liliaceous plant, divided into two branches, each of which supports a flat disc, which may represent the flower: upon this disc a lamp was placed. At the base is a mass of bronze, which gives stability to the whole; upon it a Silenus is seated, earnestly engaged in trying to pour wine from a skin which he holds in his left hand into a cup in his right. This figure is said to be wrought with wonderful skill; presenting with great effect all the characteristics which the Romans were wont to attribute to this god.

Fig. 266 is a very rich specimen in marble, contained in the British Museum; it is rather more than four feet in height, and most profusely and elegantly decorated. Various specimens are grouped in Figs. 267, 268; of which the largest presents an extraordinary instance of minute and sumptuous enrichment.

As to the adaptation of candelabra for particular purposes, it has been found that those used in public edifices were usually of considerable size, and made with a large cup at the top to receive a lamp or sufficient unctuous material to feed a large flame; as were also those employed for burning incense in the Temple. Those, on the other hand, which have been discovered in the private dwellings of the ruined cities consist generally of tall slender bronze stands, having at the top a flat circular tablet to hold a lamp, or a vase-like vessel fitted to contain oil, and having also projecting feet at the bottom of the long stem.

The lamps themselves, for the support of which these candelabra were made, were very simple pieces of mechanism. In the British Museum are numerous examples of such lamps, which must be familiar to most of the visitors. Throughout the early ages the lamps employed bore a general resemblance one to another; and if we look at those depicted in Fig. 269, we shall have a sufficiently accurate idea of their usual appearance; for although these are Egyptian lamps, they differ but little (except perhaps in the material) from those used in other countries. There was one orifice at which the oil was introduced, and another for the reception of the few filaments which served as a wick.

But lamps were only one form of the ancient means of illumination. There were torches, flambeaux, lanterns, and cressets, of various kinds. Although we may not have actual specimens to illustrate the former existence of these things, yet the devices in gems and sculptures afford sufficient evidence of it. Thus, some of the Roman gems contain representations of flambeaux such as those in Figs. 270, 271; and the latter figure also shows at *a*, a simple kind of Roman lantern, *b* and *c* being the flambeaux.

Lanterns, Torches, and Cressets, in the East.

When we descend from ancient times to the present, and glance at Oriental usages in these matters, we find that numerous forms of such instruments are found in those countries which travellers have laid open to our view. Candles, for a reason before alluded to, can hardly exist in the hot tropical climates; and therefore in most cases the arrangements are such as are fitted for the ignition of oil, or of resinous wood.

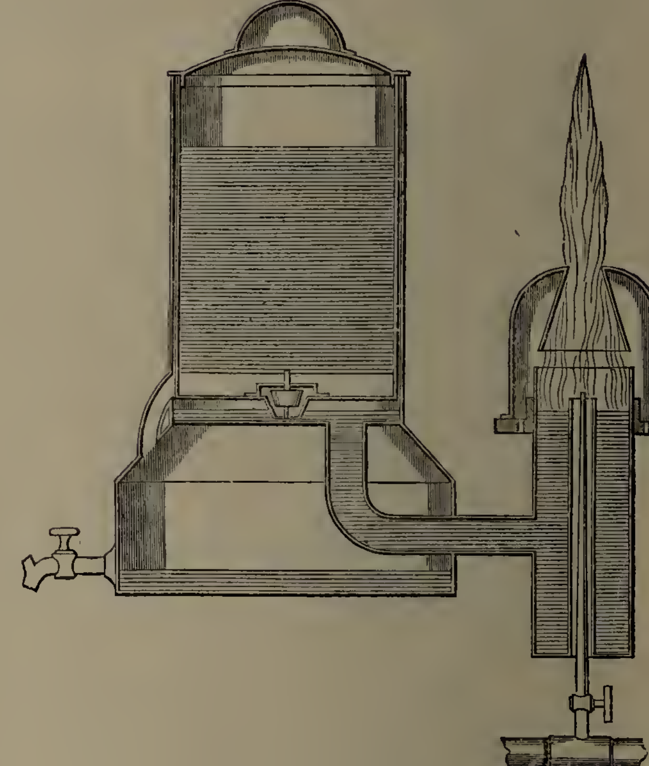
282.—Lanterns—Shakspere's time.

283.—Cressets and Road-light, 16th Century.

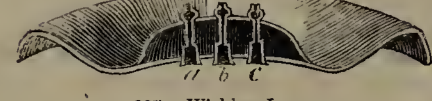
284.—Street Lantern—James I.'s reign.

285.—London Street-lights, 1760.

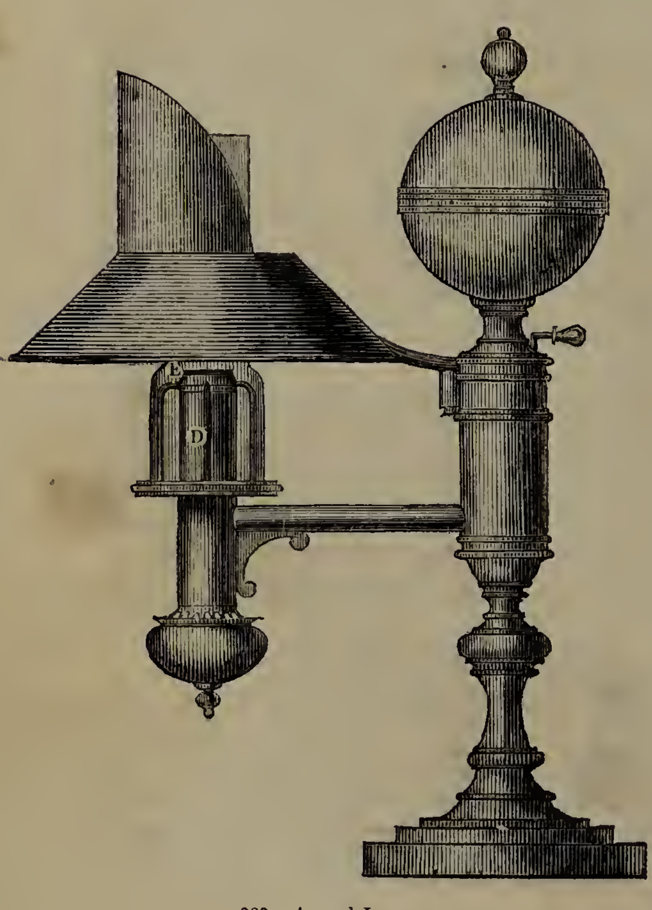
286.—Fixed Candlestick.



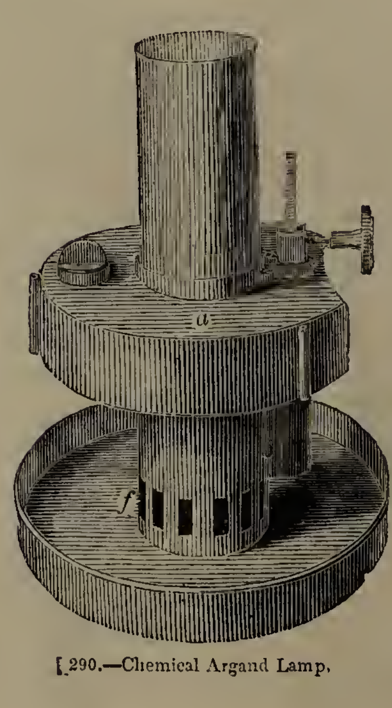
291.—Lamp for burning Gas-tar.



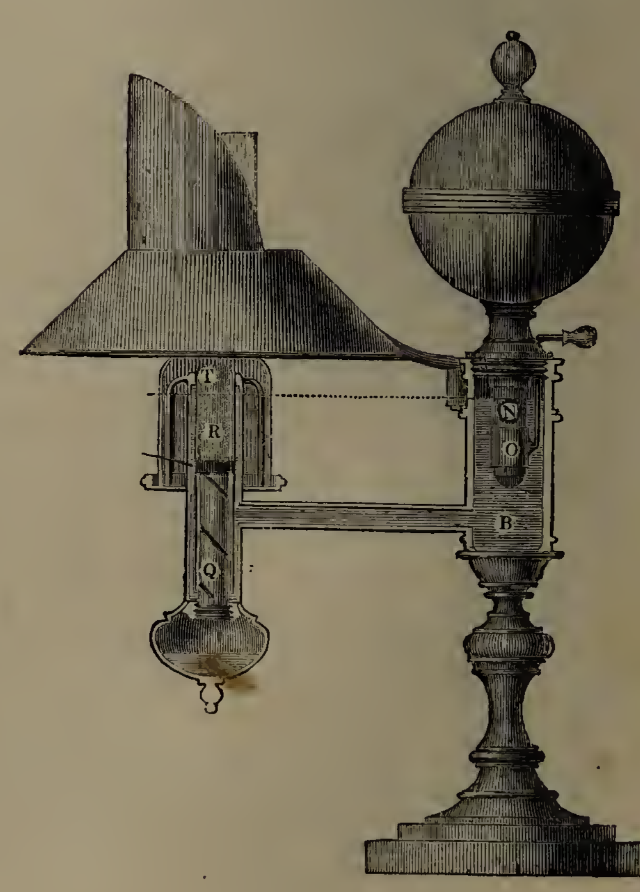
287.—Wickless Lamp.



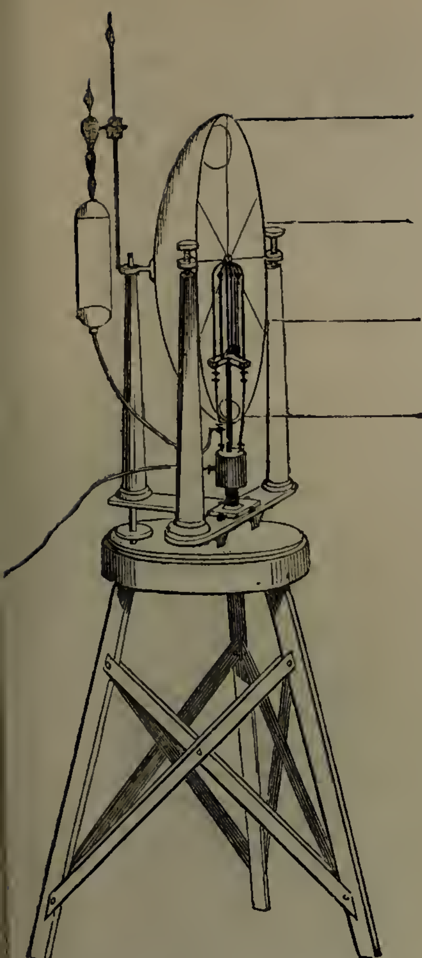
288.—Argand Lamp.



290.—Chemical Argand Lamp.

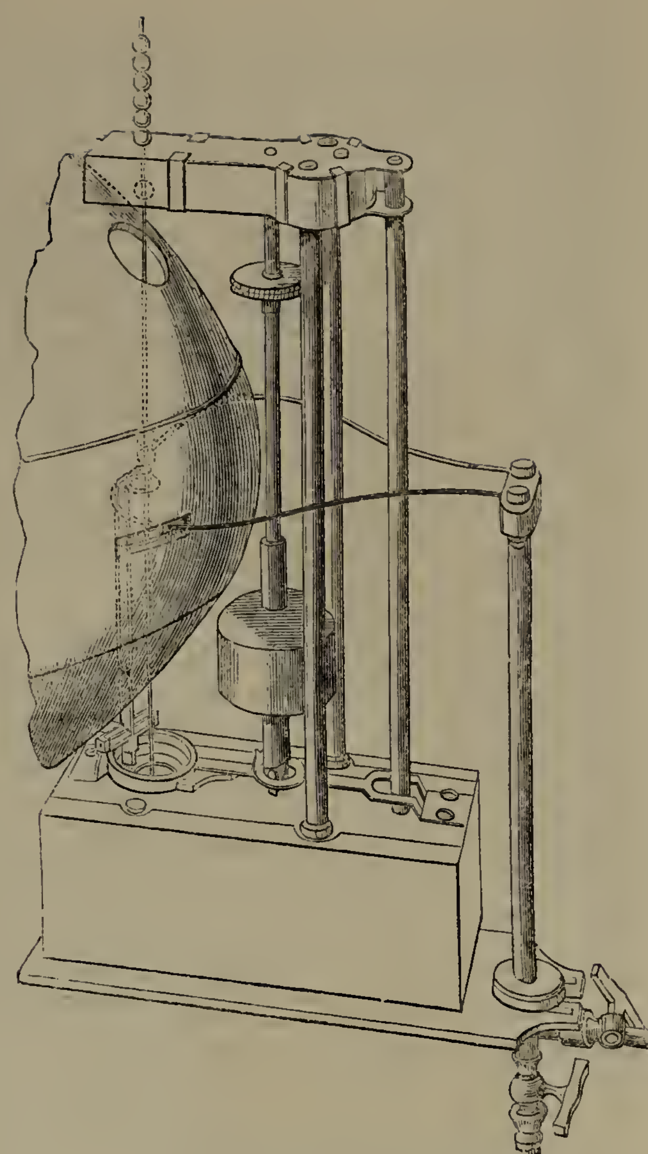


289.—Interior of Argand Lamp.

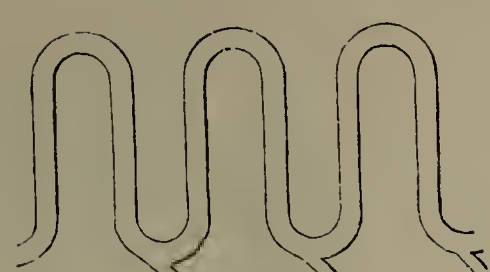


292.—Mechanism of the Drummond Light.

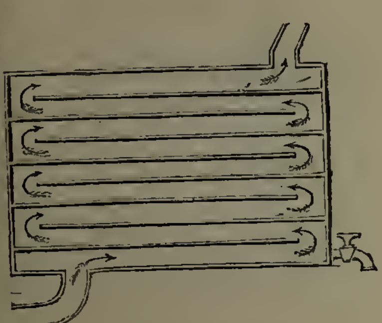
294.—London Lamplighter, 1800.



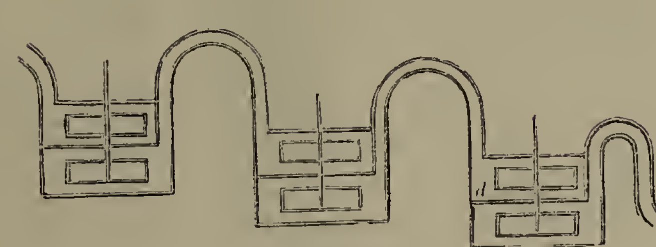
293.—Mechanism of the Drummond Light.



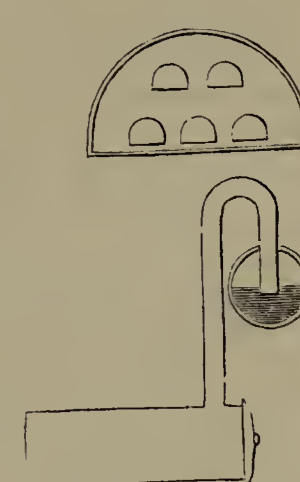
299.—Gas-condenser.



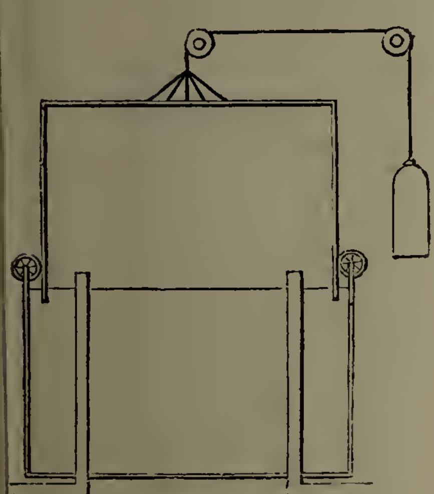
298.—Gas-purifier.



300.—Gas-purifier.

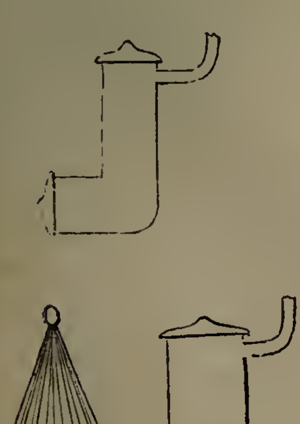


297.—Gas-retort.

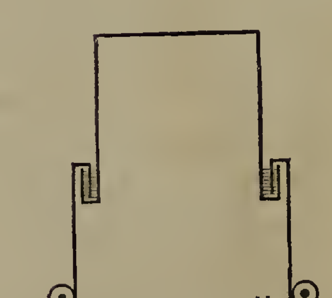


301.—Gasometer.

295.—Large Gas-meter; Westminster Gas-works.



296.—Forms of Gas-retorts.



02.—Gasometer.

In Persia lanterns and torches have been seen in operation by Morier, Malcolm, and other travellers, such as those sketched in Figs. 272, 273, 274. One of these seems to consist of a kind of cylindrical bladder or film of some translucent substance, so far flexible as to be folded up into a very portable and convenient form, and yet calculated to act as a lantern when hanging freely downward. Another lantern seems to bear a closer resemblance to those used in our own countries. The torches are of that kind to which the name of "cressets" is often given; being simply a vessel placed at the upper end of a staff, pole, or support, and capable of holding any resinous, or oily, or coal-like substance fitted to yield light when ignited. In Syria, too, such cressets (Fig. 275) are sometimes seen mounted on a very high staff, so as to throw light around to a considerable distance. The Rev. Mr. Monro, while travelling in Syria about ten years ago, witnessed an encampment of pilgrims on the banks of the Jordan. "At night," says he, "the camp was illuminated by large wood-fires, and a bituminous substance secured in small cages or beacons formed of iron hoops stuck upon poles, threw a brilliant light upon surrounding objects. This is that bitumen from the hills bordering the Dead Sea, which Maundrell describes as smelling insufferably when burnt."

Modern Egypt is not wanting in ingenious specimens of this kind. Mr. Lane, while describing the habits of the better classes in Cairo, and the general mode of spending the evening, says—"The men often pay evening visits to their friends at or after supper-time. They commonly use, on this and similar occasions, a folding lantern (*fa'nod's*) composed of waxed cloth strained over rings of wire, and a top and bottom of turned copper." The lantern here alluded to, evidently analogous to one of the Persian kind, is sketched in the left hand of Fig. 276. The right hand of the same cut represents a lamp or *chandee'l* (a word bearing a strong resemblance in sound to our "candle"). The lamp is a small glass vessel, having a little tube in the bottom for the reception of a wick formed of cotton twisted round a piece of straw: water is poured into the lamp first, and then oil. The lamp is shown both separately, and in connexion with a wooden covering which serves to protect the flame from the wind.

The interior of the best Egyptian houses is somewhat dull at night; for even a large room generally presents nothing more than one or two small lights, the flame of which is protected from the wind by a glass shade or lantern. Over the entrance to a house is often placed a lamp such as has just been described. On festive occasions, however, the illumination is more brilliant. It is at bridal ceremonies that these illuminations principally take place. For the space of two or three evenings before the marriage is to take place, the street or quarter in which the bridegroom lives is illuminated with chandeliers and lanterns, or with lanterns and small lamps (Fig. 277) suspended from cords drawn across from house to house; decorated also with coloured flags. On one of the evenings, too, the bridegroom goes to mosque in procession, attended by musicians with drums and hautboys, and with men bearing *mesh'als*. These are receptacles or open grates, supported on poles, and containing flaming wood (Fig. 278).

The Chinese have acquired for themselves quite a reputation in respect to the manufacture and tasteful decoration of their lanterns (Fig. 279). At the "Chinese Exhibition" in London, specimens of a really magnificent kind are presented to the eye, such as none other than these singular people have ever made.

Bell, who witnessed the "Feast of Lanterns" at Pekin in the early part of the last century, thus describes it:—"About five of the clock a signal was given for beginning to play off the fire-works, by a rocket let fly from the gallery where the Emperor sat; and in the space of a few minutes many thousand lanterns were lighted. These lanterns were made of paper of different colours, red, blue, green, and yellow; and hung on posts about six feet high, scattered over all the garden; which exhibited a very pleasant prospect to the eye." Rockets were then let off, after which the lantern exploits were continued.—"Opposite the gallery where the Emperor sat was suspended a large round vessel, about twenty feet in diameter, between two posts about thirty feet high. A rocket sent from the gallery lighted a match hanging from the vessel, which immediately caused the bottom of it to drop down with a loud noise. Then fell out a lattice or grate-work, all on fire, and hung between the vessel and the ground, burning furiously in various colours. This continued for ten minutes, and really exhibited a most curious sight. It seems this lattice-work was composed of materials that immediately kindled on being exposed to the air; for no person was seen near the machine. The grate-work being extinguished, there appeared a lighted match hanging from the middle of the vessel, and burning up to it. As soon as the fire reached the vessel, thirty-five paper lanterns, of various colours, dropped from it, and hung in a straight line below one another, between it and the ground, which immediately catched fire of themselves, and formed a beautiful and well-proportioned column of party-coloured light. After this fell out about ten or twelve pillars of the same form, but of a lesser size: these also took fire as soon as they dropped. This scene continued till the number of one thousand lanterns fell from the vessel, which diminished every time, till the last was very small. I must confess this presented a delightful object to the spectators. I could not help being surprised at the ingenuity of the artist, in crowding such a number of lanterns into so small and simple a machine as this seemed to be; and at the same time, with so much order, that all of them dropped and kindled of themselves with equal regularity as if he had let them fall from his hands; for not even one of them was extinguished by accident, or in the least entangled by another."

English Street Lights, in past Times.

Without stopping to notice the minor differences observable in the light-giving arrangements of other Eastern nations, it will be well now to come nearer home, and glance at past usages in our own and neighbouring countries.

Beckmann collected a good deal of information as to the time when and the mode in which the principal cities of Europe began to be lighted. There seems no evidence to prove that any system of street-lighting was regularly acted on till about the sixteenth century, when Paris took the lead. At that time the French metropolis was much infested with street-robbers in the night-time, and the inhabitants were ordered to keep lights burning before their houses during the night. In 1558 the police authorities of the city ordered that at the corners of the principal streets should be set up *fallots*, which were large vases filled with pitch, resin, and other combustible matter. The regulation of the flame from these fallots, however, was so bad, that they were afterwards superseded by lanterns. The next step arose out of a private speculation on the part of an Italian named Laudati. This person, in the year 1662, obtained an exclusive privilege, for twenty years, of erecting, not only in Paris, but also in other towns of the kingdom, booths or posts, where any person might hire a link or lantern, which he might either carry or hire a person to carry for him. Laudati was authorised to receive from every one who hired a lantern to a coach, five sous, and for every foot-passenger three sous, for a quarter of an hour; and to prevent disputes in regard to time, it was ordered that a regulated hour-glass should be carried along with each lantern.

This system of Laudati's was convenient so far as it went, but it left untouched the necessity for permanent lights under a central controul. Shortly afterwards the stationary lanterns were improved in form and increased in number; they had previously been used only in the four winter months, but they now came to be lighted during the whole year. Next arose the method of using the *reverberating* lamps, as they were termed; that is, lamps which were suspended from a string that crossed the street from side to side, and hung over the carriage-way at such a height as to permit vehicles to pass beneath them. This Parisian mode of lighting the streets was thus quaintly described by Dr. Martin Lister, who visited the French metropolis in the time of Louis XIV.:—"The streets are lighted alike all the winter long, as well when the moon shines as at other times of the month; which I remember the rather because of the impertinent usage of our people of London, to take away the lights for half of the month, as though the moon was certain to shine and light the streets, and that there could be no cloudy weather in winter. The lanthorns here hang down in the very middle of all the streets, about twenty paces' distance, and twenty foot high. They are made of a square of glass about two foot deep, covered with a broad plate of iron; and the rope that lets them down is secured and locked up in an iron funnel and little trunk fastened into the wall of the house. These lanthorns have candles of four in the pound in them, which last burning till after midnight." To this follows a significant allusion to a piece of mischief not wholly unknown to the "scape-graces" of London: "As to these lights, if any man break them he is forthwith sent to the galleys; and there were three young gentlemen of good families, who were in prison for having done it in a frolic, and could not be released thence in some months, and that not without the diligent application of good friends at court."

Of other important cities on the Continent, it has been ascertained by Beckmann, that at Vienna, until about seventy years ago, the inhabitants had to take or send the street-lamps to the "lamp-office" every morning, to have them filled with oil, and had then to place them up in front of their houses during the night —the government, in fact, supplying the lights, but the inhabitants themselves taking the duties of lamp-lighters. But after the period named, a body of lamp-lighters wearing a uniform, and being under military discipline, was appointed in Vienna. In Berlin, the system of lighting the streets commenced by the inhabitants of every third house being ordered to hang out, in turns, a lantern before their doors. After this, the city authorities adopted the erection of lamp-posts, the lamps for which were kept lighted at the expense of the inhabitants. In Amsterdam, an order was issued by the magistrates at the close of the seventeenth century, to the effect that the lamplighters should "wipe the oil and dirt off the horn of the lanterns every day, and that horses should not be fastened to the lamp-posts;" from which we may easily infer as to the kind of street-lamps then used. The streets of modern Rome were not lighted at all until a very late period; and it is stated that Pope Sixtus the Sixth ordered that the number of lights placed before images of saints in the public places should be increased, as a means of lessening the darkness of the streets. Generally speaking, it was in the seventeenth century that towns of importance, such as Hamburg, Venice, Madrid, the Hague, Copenhagen, Messina, and Palermo, began to adopt the practice of permanent street lighting at night.

Now we come to our own busy city, as a representative of the best method (for so we may naturally conclude) adopted at any particular time.

Until about the commencement of the fourteenth century, there was no provision for lighting the streets of London, except by the lanterns or torches which the inhabitants carried with them, or chose voluntarily to hang outside their houses. But in the year 1416, the Mayor, Sir Henry Barton, ordered lanterns and lights to be hung out in winter from Allhallows to Candlemas. For the long period of three centuries down to the reign of Queen Anne, this plan, or rather no-plan, seems to have been acted on: the city authorities continued to issue the order, and the citizens continued to obey or to evade the order according as their patriotism or their parsimony happened to be in the ascendant. In many of our poets and chroniclers numberless allusions are found bearing upon this custom; from which it appears that the watchmen, whose main duty was to guard the streets, also acted as monitors to remind the citizens of their obligation to hang out lights before their houses. In early times the watchmen were well-armed men; but by degrees they degenerated into the decrepit and feeble old men who were a laughing-stock till within the last twenty years. There is an old print of the time of James I., from which Fig. 284 is taken, and under which are a few rhyming lines, seeming to have formed one of the many varieties of watchmen's cries at that time:—

> "A light, here, maids, hang out your light,
> And see your horns be clear and bright,
> That so your candle clear may shine,
> Continuing from six till nine;
> That honest men that walk along
> May see to pass safe without wrong."

The lantern carried by these men bore a tolerably close resemblance to the commonest of those now used. The men had a long stick or staff in addition to their lantern. Some of the old prints represent the watchmen thus accoutred; while others exhibit them as provided also with bells, as in Fig. 280; and the staff is occasionally changed for a more dangerous weapon. For domestic purposes many forms of lanterns were used (Fig. 282), differing more or less from those of the watchmen.

But this kind of stationary watch, in which the lantern was a part of the paraphernalia, was preceded by a system in which the "cresset" was used instead of the lantern. Many of Hollar's prints, relating to the state of things in the sixteenth century, contain representations of the watchmen of those times, dressed in a costume far more picturesque than any pertaining to our common ideas of a watchman, and bearing cressets mounted on poles reaching far above their heads. In Fig. 283 are grouped many of these figures carrying four or five different forms of cressets, but all capable of holding resinous or pitchy materials for light. One of these, a fixed cresset, surmounts a pole provided with steps or ledges calculated to serve as a ladder.

There was, in the time of Henry VIII., an imposing and somewhat gorgeous pageant occasionally performed in the city, in which the carrying of beacon-cressets was a distinguished feature. This procession was called the "Marching-Watch." To one of these cavalcades, which occurred in the early part of Henry VIII.'s reign, the following description relates, taken from 'London,' No. 6, "Midsummer Eve:"—"Onward came the Marching-Watch, winding into Cheap by the little Conduit from Paul's Gate. Here, literally,

> "The front of heaven was full of fiery shapes,
> Of burning vessels."

The pitchy ropes borne aloft in iron frames sent up their tongues of fire and wreaths of smoke in volumes which showed, afar off, like the light of a burning city. Stow tells us that for the "furniture" of the Marching-Watch there were appointed seven hundred cressets; besides which every constable, amounting to two hundred and forty, had his cresset. Each cresset had a man to bear it and another to serve it, so that the cresset-train amounted in number to almost two thousand men. This was, indeed, civic pomp upon a splendid scale. A poet of the next century, whose name is almost unknown in the ordinary catalogues of English poetry, but who has written with more elegance and truth than half of those we call classics—Richard Niccols, in a performance called 'London's

Artillery,' has the following very beautiful lines descriptive of the bonfires and cresset-lights of the great festival of the summer solstice:—

> "The wakeful shepherd by his flock in field,
> With wonder at that time far off beheld
> The wanton shine of thy triumphant fires
> Playing upon the tops of thy tall spires."

Mingled with the cresset-bearers came on two thousand men of the Marching-Watch, some mounted, and some on foot. There were demilances on great horses; gunners with their harquebusses and wheel-locks; archers in white coats with bows bent and sheafs of arrows by their sides; pikemen in bright corslets; and billmen with aprons of mail. Following these came the constables of the watch, each in bright harness gleaming from beneath his scarlet jornet, and his golden chain, with his henchman following him, and his minstrel before him, and his cresset-light by his side. . . . . . Onward swept the mighty cavalcade past the Cross at Cheap, along Cornhill, and by Leadenhall to Aldgate; it was to return by Fenchurch Street and Gracious (Gracechurch) Street, and again into Cornhill and through Cheapside."

But all these trappings bore relation to a holiday, and not to the effective lighting of the city. In 1569 the "Marching-Watch" was put down, with a view "in the room thereof to have a substantial standing-watch, for the safety and preservation of the city." The lantern-watch succeeded it, with the modifications before alluded to. Until 1690 the obligations of the citizens as to lighting the fronts of their houses were rather of a vague character; but in that year the order was made more exact, by specifying that every housekeeper should hang out a lamp or lantern every night as soon as it was dark, from Michaelmas to Lady-day, and to keep it burning until midnight. Again, about thirty years afterwards, the common council ordered that all housekeepers whose houses fronted any street, lane, or public passage, should, "on every dark night, that is, every night from the second night after full moon to the seventh night after new moon, hang out one or more lights, with sufficient cotton wicks, to continue burning from six till eleven o'clock in the evening, under the penalty of one shilling.

In the meantime a licence had been granted to certain parties "concerned and interested in glass-lights, commonly called or known by the name of convex lights," to supply such of the street lamps as were supported by the corporation. But for many years the arrangements were lamentably deficient. In 1736 the corporation applied to Parliament for power to enable them to light the streets in a better manner. The act which they obtained empowered them to set up a sufficient number of glass lamps, which were to be kept burning from sunset to sunrise throughout the year. The result of this was that nearly five thousand street lamps were erected within the city. This was the commencement of the state of things which, subject to gradual modifications, lasted till within reach of the present generation—to be then superseded by the most valuable and important discovery ever made in the system of lighting towns.

There was a subsidiary army of torches, links, and flambeaux, throughout the last century, to aid in the common object which the street lamps effected in only a very dim manner. It was customary both for pedestrians and for persons riding in carriages to have the services of link or flambeaux bearers. Many of Hogarth's pictures contain representations bearing on this point. The few scattered lamps in the principal streets, and the lanterns carried by the watchmen, were useful so far as their glimmering extended; but the link-boys (Fig. 285) picked up a living by lighting gentlemen through the (then) narrow and winding streets of the metropolis. It has probably been remarked by many persons that in the better class of houses at the west end of London, built in the last century, are still occasionally to be seen a kind of extinguisher placed on either side of the door, supported by the iron railings. These were so placed to enable servants, after having dismounted from behind a carriage, to extinguish the flambeaux which they often carried with them.

Of the brilliant and invaluable *gas* which has superseded alike the old street lamps and the portable flambeaux and links of olden time, we have yet to speak; but before doing so, it will be well to glance at

Modern Lamps.

There has been a good deal of scientific ingenuity displayed within the last few years in the construction of lamps for domestic purposes, as well as for shops and public buildings. In olden times the lamps, if intended for the consumption of oil, were of very simple character, and were placed in any kind of stand indiscriminately. Candles too, as well as torches, or substitutes for torches, were, in domestic apartments, placed in holders of various kinds. Some old candlesticks still remaining, such as that sketched in Fig. 286, represent a soldier, or armed man, holding vertically in each hand a lance or staff, on the upper end of which was placed the light. An allusion to a "fixed candlestick" of this kind occurs in Shakspere. It is in 'Henry V.,' where the French nobles, assembled in the camp at Agincourt, are vapouring about their superiority over the English. Grandpré says—

> "Big Mars seems bankrupt to their beggar'd host,
> And faintly through a rusty beaver peeps;
> Their horsemen sit like 'fixed candlesticks,'
> With torch-staves in their hands;"

—a simile which was far from being borne out by the result of the approaching battle.

There has also been put upon record the use of a *living* candlestick, arising out of the use of pine-splints in Scotland for flambeaux. Sir Walter Scott has thus woven the incident into his 'Legend of Montrose.' Donald, the old servant of Angus M'Auley, is relating a circumstance in which his master was concerned:—"When our laird was up in England, where he gangs oftener than his friends can wish, he was biding at the house o' this Sir Miles Musgrave, an' there was putten on the table six candlesticks, that they tell me were twice as muckle as the candlesticks in Dumblane Kirk, and neithern airn, brass, nor tin, but a' solid silver, nae less;—up wi' their English pride, hae sae muckle, and ken sae little how to guide it! Sae they began to jeer the laird, that he saw nae sic graith in his ain poor country; and the laird, scorning to hae his country put down without a word for its credit, swore, like a gude Scotsman, that he had mair candlesticks, and better candlesticks, in his ain castle at haim, than were ever lighted in a hall in Cumberland." A wager ot two hundred marks was laid and accepted: the gentlemen visited the Scotch laird's house some time afterwards; and in the dining-hall the following scene met their view:—"The large oaken table was spread with substantial joints of meat, and seats were placed in order for the guests. Behind every seat stood a gigantic Highlander, completely dressed and armed after the fashion of his country, holding in his right hand his drawn sword, with the point turned downwards, and in the left a blazing torch made of the bog-pine. This wood, found in the morasses, is so full of turpentine, that, when split and dried, it is frequently used in the Highlands instead of candles. The unexpected and somewhat startling apparition was seen by the red glare of the torches, which displayed the wild features, unusual dress, and glittering arms of those who bore them; while the smoke, eddying up to the roof of the hall, overcanopied them with a volume of vapour." These bold Highlanders were the "candlesticks," more precious and more effective in the laird's eyes than if they had been of silver; and he was adjudged to have won the wager.

The lamps, which have superseded these usages of a past age, act on a principle before alluded to, viz., the combustion of oil divided into a number of minute streams by the interposition of filaments of cotton. We gave in a former page a sketch of an arrangement whereby the use of these filaments is dispensed with, by employing a siphon-tube of very small bore; and Fig. 287 shows another mode where, by allowing the oil to ascend two or three small tubes, *a, b, c*, the same result is brought about. But in all common cases a wick is invariably employed; and a good deal of ingenuity is shown in the mode of arranging this wick.

Until the invention of the *Argand* lamp, the wick was usually a roll or bunch of cotton threads, twisted slightly around each other; and many improvements were introduced from time to time to regulate the equable flow of oil to this wick. But it was not until M. Argand of Geneva, about sixty years ago, took up the matter, that arrangements were made to provide a more abundant access of fresh air—a point which had always been defective in the common lamps up to that period. So long as a wick is very small, the flame is also small; but, at the same time, it is brilliant, because the whole of the flame is in immediate contact with the air which feeds it. But when, in order to increase the body of the flame, the wick is made thicker, a serious defect is at once produced; the interior portion, being enveloped by the outer, is excluded from the action of the air, whereby the gaseous matter is but imperfectly inflamed, and the light is in consequence obscure and dull, much of the vaporized oil passing off in smoke without being kindled at all. One mode of obviating this evil, when it was absolutely necessary to increase the size of the flame, was to make a flat wick, or a number of little wicks side by side, so that there should be no part far removed from access to the air.

Argand, however, conceived the happy idea of making the wick *circular*, or in form of a hollow cylinder, and so adjusting the apparatus in which it was placed as to allow air to approach both within and without this cylinder. He proceeded as follows. He procured a small tube, about three inches long by half an inch in diameter, and soldered it at one end withinside another tube of the same length but double the diameter, leaving between the two a space open at one end and closed at the other. A wick was formed by a piece of cotton woven cylindrically without a seam, and fixed to a brass ring fitted to the space between the two tubes. A worm or groove was cut in the inner tube to facilitate the raising and lowering of the wick. The oil was admitted to the wick by a pipe connected with the oil vessel, and passing through the outer tube. The wick being then kindled, a ring of light was formed, fed by fresh air both from within and from without. But the intensity of the light did not answer Argand's expectations: it was neither brilliant nor large, and every attempt to improve it by using more oil or more wick only produced smoke. Argand tried earnestly to find out how this arose; and his brother thus relates what occurred:—"My brother had long been trying to bring his lamp to bear. A broken neck of a flask lying upon the chimney-piece, I happened to reach it over to the table, and to place it over the circular flame of the lamp. Immediately it rose with brilliancy. My brother started from his seat with ecstacy, rushed upon me in a transport of joy, and embraced me with rapture." Thus arose the use of the glass "chimney," now always employed with the Argand lamp, and which answers a double purpose: it prevents air from having access to the flame except at its lowest part, where it is most serviceable; and it occasions a draught or rapid ascent of heated air, which is itself one of the conditions of perfect combustion.

The arrangement of an Argand lamp, provided with various little appendages introduced from time to time, may be seen from Figs. 288, 289, of which the former shows the external appearance, and the latter the interior section. Taking the former or external figure first, it will be seen that there is a globular vessel to act as an oil reservoir, the oil from which descends gradually, and then passes along a horizontal tube to the burner D. This burner contains the wick, placed between two tubes and immersed in oil, and rising a little above the top of the burner at E. Over this is the glass chimney, with the lower part enlarged to increase the current of air; the chimney rests on a kind of gallery, and is kept in its place by four wires: by turning this gallery, the wick is either raised or lowered. At the bottom of the burner is a small cup to receive any drops of oil which may fall; and just above this are several small holes to admit air to the interior of the wick, the exterior being fed by air which finds its way within the bottom of the chimney. Near the globular reservoir is a small handle for regulating the flow of oil into the burner; and over the upper half of the chimney is a shade which fits the apparatus to serve as a "reading-lamp." We may next inspect the interior arrangements (Fig. 289). The neck of the globular reservoir is here seen to dip into a lower vessel. The reservoir, when taken out, is filled with oil at the hole N; and this hole is closed up by a slide O, governed by the little external handle. When adjusted to its place, and the hole again opened, the oil flows out into the cistern B, and thence along the horizontal tube to the burner. Q is the inner tube, and R is the wick, rising a little above the burner at T. The dotted line shows the level to which the oil will always be maintained, on account of the relative position of the burner and the hole in the reservoir.

Another form of Argand lamp (Fig. 290) is much used in chemical experiment. Here the reservoir of oil is at *a*; above it is a small copper chimney; beneath it is a wick raised or lowered by a rack and pinion seen outside; at *f* are holes to admit air to act on the flame; and beneath all is a dish or stand to catch any oil that may drop from the reservoir.

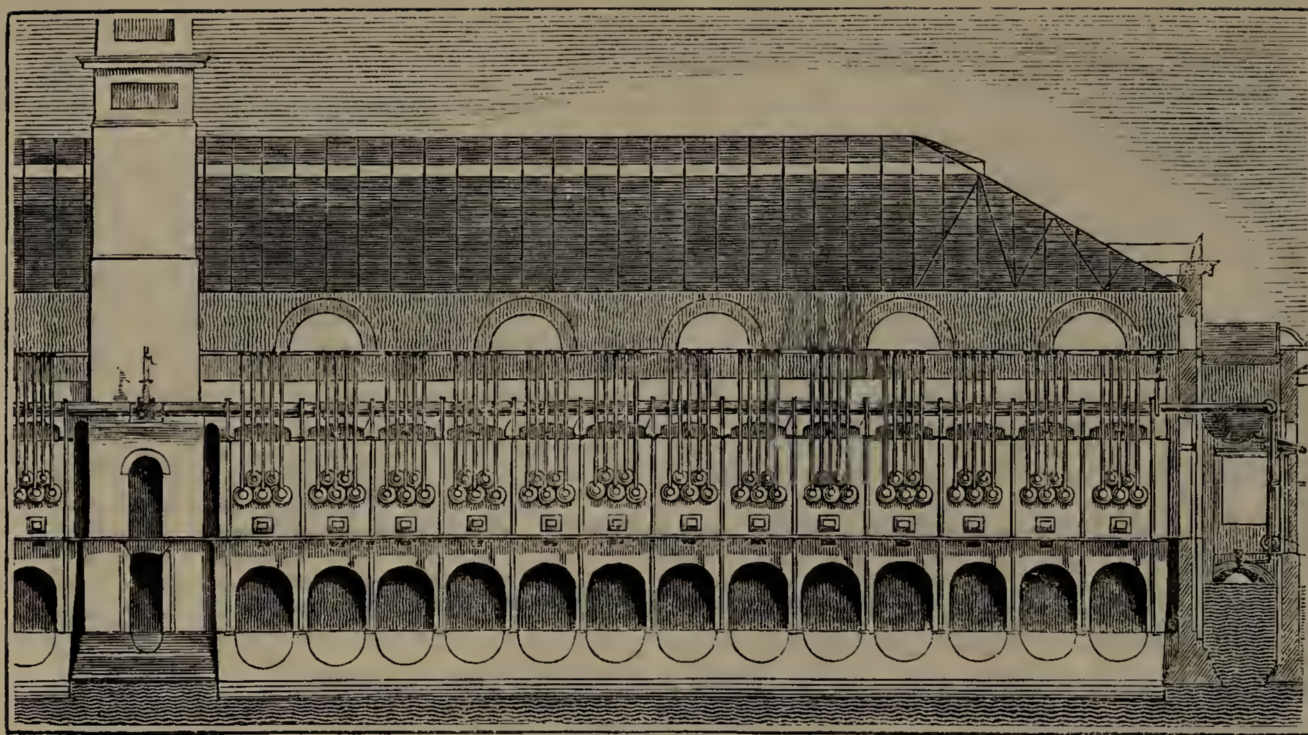
All the numerous varieties of "table-lamps" are modifications of the Argand. There is a circular wick, a glass chimney, and the other numerous little appendages near the burner; but the oil, instead of being contained in a globular receiver, is poured into a ring-like vessel which surrounds the burner, and from which it flows through lateral tubes.

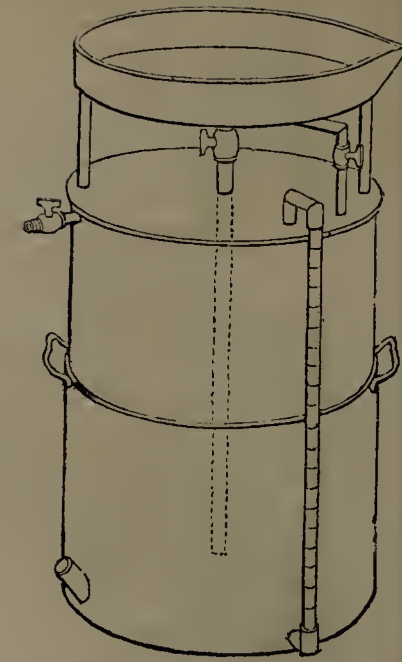
Minor changes in the arrangements of lamps are very numerous, some of them intended to facilitate the combustion of cheaper ingredients than whale-oil. Such, for instance, is the object of the lamp sketched in Fig. 291, which allows of gas-tar being burned instead of oil. This liquid would, under ordinary circumstances, burn with a very weak flame; but, by the arrangement here adopted, a brilliant light is procured. The general construction of the lamp bears a resemblance to the Argand; but the interior of the flame is fed with *condensed* air, derived from a pipe connected with other apparatus. It is only in manufactories where condensing apparatus is at hand, that such a lamp is available; but under such circumstances the light is said to be exceedingly brilliant.

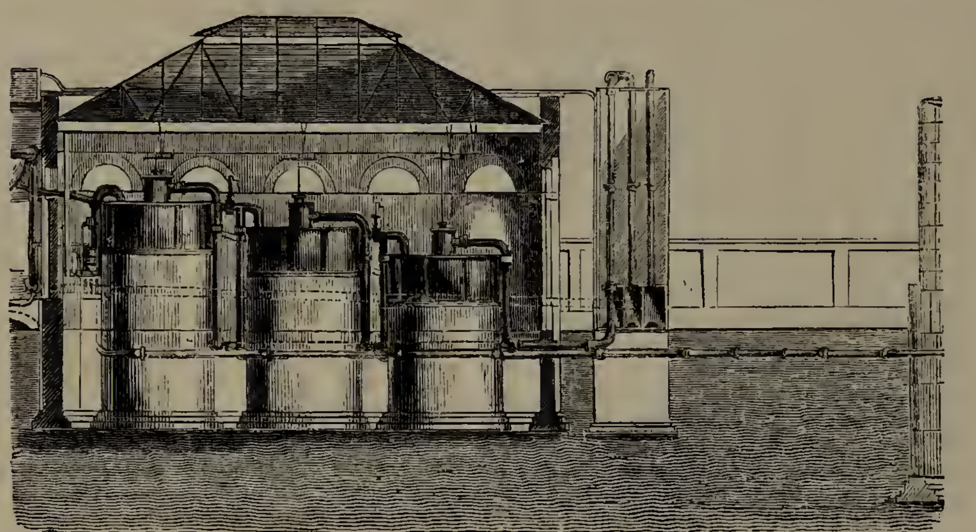
Bude Light and Drummond Light.

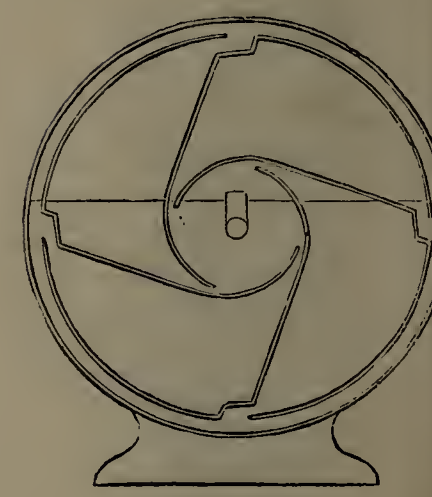
The means of procuring an intense light have occupied a great deal of attention within the last few years; and the experiments made at the House of Commons have done much to advance the matter.

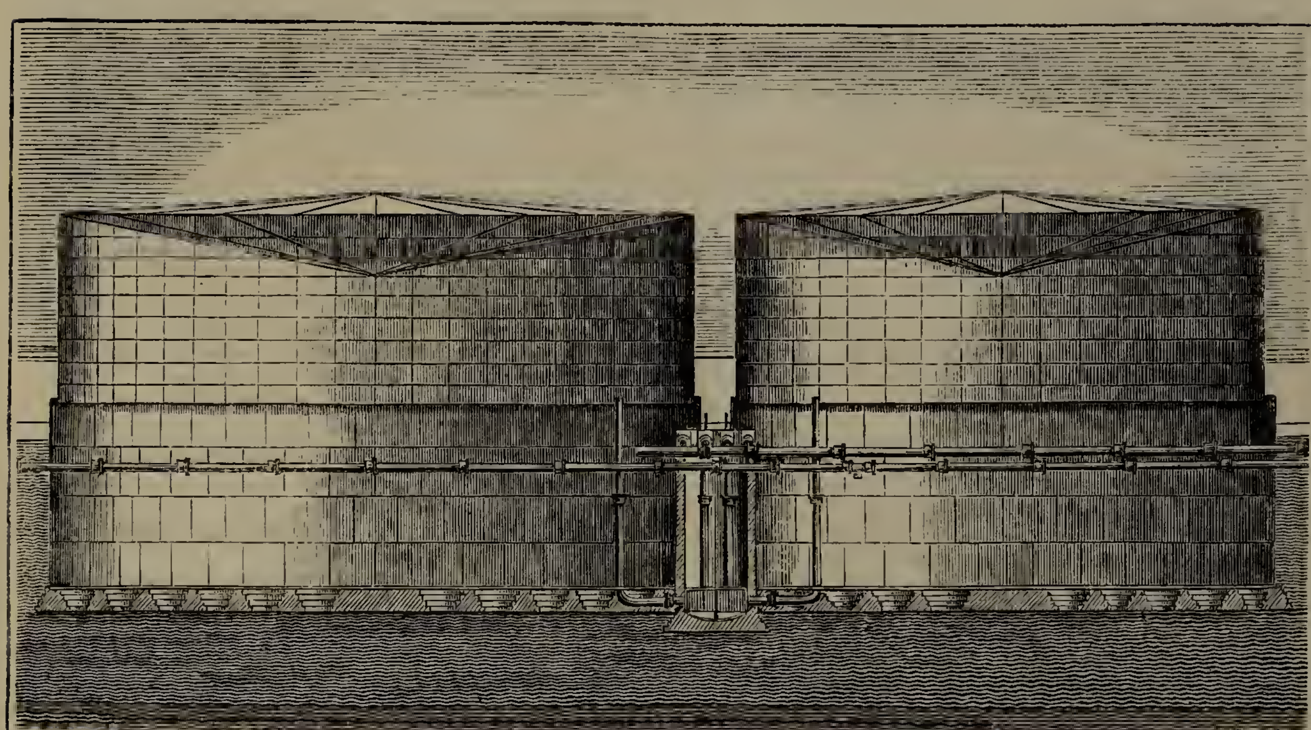
The Bude-light, or the oxy-oil light (as it was at one time called), has undergone singular changes since it was first proposed a few years ago. In its first form the principle consisted mainly in passing up a current of oxygen-gas, instead of common air, into the Argand lamp. Inside the hollow wick of the lamp, and carried up nearly to its top, was a tube connected at the lower end with a gasometer containing oxygen-gas; and when the lamp was lighted, the gas was allowed to ascend so as to feed the interior of the cylindrical

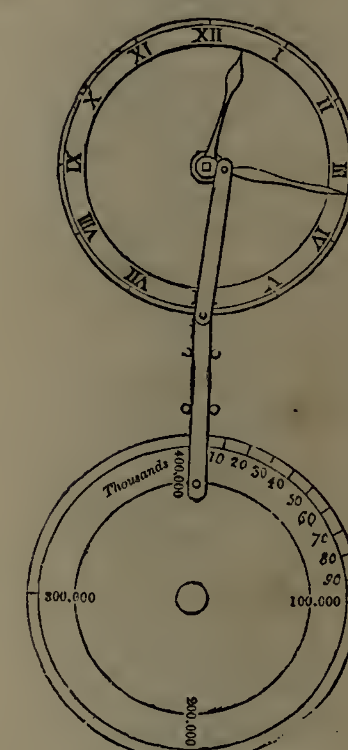

303.—Retort-House.


306.—Gasometer.

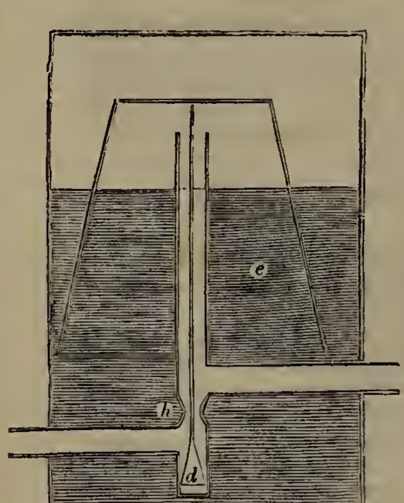

304.—Gas Purifiers and Condensers.


307.—Gas-meter.

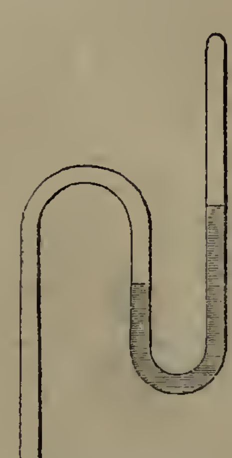

305.—Gasometers.

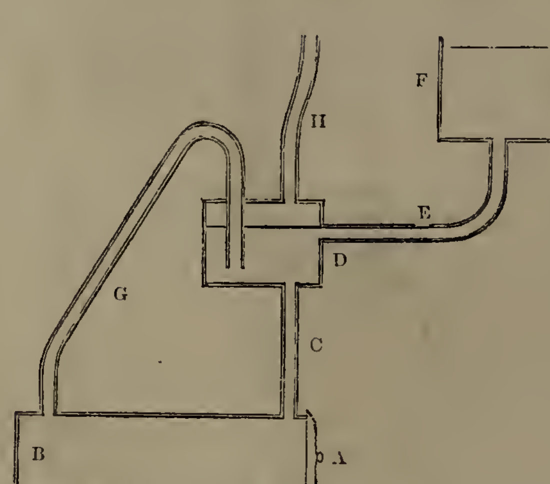


309.—The "Tell-tale" of Gas-meter.

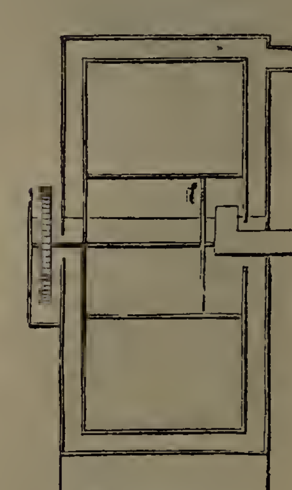


310.—Gas governor.


311.—Gas-pressure Gauge.



312.—Oil-gas apparatus.



308.—Gas-meter.

313.—Greek Drapery. (From the Elgin Marbles.)

316.—Draped Figures. (From the Townley Gallery.)

315.—Greek Drapery. (From the Elgin Marbles.)

318.—Roman Plebeian Dress.

314.—Greek Drapery. (From the Elgin Marbles.)

317.—From a Painting at Pompeii.

319.—Roman Domestic Dress. (From a Painting at Pompeii.)

320.—Roman Drapery. (From a Painting at Pompeii.)

flame, by which a flame of great brilliancy was produced. After this, many experiments were made to test the availability of this light for lighting the House of Commons, and also for the burners of lighthouses. In these experiments it was found that the use of liquid oil involved many inconveniences, and oil-vapour was substituted for it; then oil-gas was employed; and at length the gas of the streets became used. As the combustible was thus changed, so was also the supporter of combustion. The making of oxygen gas is a troublesome and expensive process; and Mr. Gurney, the inventor of the light, sought to obviate the necessity for using it. He conceived that the common air of a room, if brought to act on a gas-flame in a particular manner, might produce a result vastly superior to that commonly produced in gas-light. The result has verified this expectation. The Bude-light now adopted in many churches, in some of the large club-houses, and elsewhere, is in fact merely a gas-light, but so carefully managed that all the gas is consumed in such a manner as to yield the greatest possible quantity of light, with the least amount of heat and of smoke.

Professor Faraday and many other men of science have also within the last few years devoted a good deal of attention to the advancement of this matter; and important improvements have resulted, chiefly from the mode in which air is allowed to have access to the flame.

Another kind of light, of extraordinary intensity, results from a chemical combustion somewhat out of the ordinary track. This is the *Drummond*, the *Lime*, or the *Oxy-hydrogen* light (for it has been called by all these names). In the trigonometrical survey of Ireland, about twenty years ago, the late Lieutenant Drummond availed himself of the intense light produced by causing a jet of oxygen gas to feed a flame in contact with a small ball of lime. The matter originated thus:—In the operations connected with a trigonometrical survey, the country is parcelled out into very large triangles, the three angles or corners of which are frequently seventy or eighty miles asunder. Some means have to be adopted for making those stations visible one from another: in some instances the sun's light is reflected from a polished speculum; in others Bengal lights are fixed off; and in others powerful Argand lamps are used, placed in front of parabolic reflectors. Lieutenant Drummond suggested the use of the lime-light; and, after a few modifications of the apparatus, succeeded in his object. Two of the stations were sixty-seven miles asunder, the one being a few miles from Londonderry and the other near Belfast. For more than two months the officers engaged could not see the signal on one of these stations from the other, owing to the haziness of the weather; but when the lime-light was employed, it was visible at once, although the luminous object was not larger than a boy's marble, and was situated from the observers nearly as far as Dover is from London! On another occasion, in some experiments made on the Thames, a lime-light was erected on a hill at Purfleet, and attended by Lieutenant Drummond; while Captain Basil Hall, stationed at Blackwall (ten miles distant in a straight line), could distinctly see the shadow of his fingers projected against a wall, when they were held up between the wall and the light!

The production of this extraordinary light depends on this circumstance — that when lime and other earthy matters are exposed to an intense heat, they become luminous to a degree scarcely conceivable. Now the flame of a spirit-lamp, fed by a jet of oxygen, produces a heat of such intensity as to give this light-yielding property to lime. As the light was to act as a signal in the open air, the apparatus comprised a good deal of complicated appliances. Fig. 292 represents some of them. A parabolic reflector was placed behind a kind of lamp, in which a ball of lime was acted on by a spirit-flame and a jet of oxygen, so as to produce light which, when reflected and focalized from the hollow side of the polished paraboloid, should be visible at a great distance. Lieutenant Drummond afterwards substituted hydrogen gas for spirit, whereby the light became an oxy-hydrogen one. This required an altered arrangement, sketched in Fig. 293, where the *back* of the reflector is towards the eye. The two gases, oxygen and hydrogen, were prepared by chemical processes, and kept in two gasometers in reservoirs. From these reservoirs pipes conveyed the respective gases to a third vessel, where they were united; and the united jet then passed through wire-gauze screens, and through a very fine tube in two branches, acting directly upon a ball of lime placed between the ends of the tubes. The greater part of the apparatus was placed behind a reflector, but the lime-ball and the gas-tube were in front of it, and in the form of the curve.

Lastly, but certainly not least, we must devote a little attention to that most admirable system, the production and distribution of

Street Gas.

In this, as in too many other cases, the first contriver or inventor of the system, the man who paved the way for all that has been since done, failed to reap the benefit which was due to his ingenuity. The circumstances connected with its introduction are thus noticed in the 'Penny Cyclopædia:'—"Although the properties of coal-gas were known to many persons, no one thought of applying it to a useful object until the year 1792, when Mr. Murdoch, an engineer, residing at Redruth in Cornwall, erected a little gasometer and apparatus, which produced gas enough to light his own house and offices. Mr. Murdoch appears to have had no imitators, but he was not discouraged; and in 1797 he erected a similar apparatus in Ayrshire, where he then resided. In the following year he was engaged to put up a gas-work at the manufactory of Boulton and Watt, at Soho. This was the first application of gas in the large way; but, excepting in manufactories or among scientific men, it excited little attention until the year 1802, when the front of the great Soho manufactory was brilliantly illuminated with it on the occasion of the public rejoicings at the peace. Accustomed as we are to the common use of gas, we cannot even now but be struck with such a display on a large scale; but the superiority of the new light over the dingy oil-lamps used in that day, when thus brought into public view, produced an astonishing effect. All Birmingham poured forth to view the spectacle, and strangers carried to every part of the country an account of what they had seen. It was spread about everywhere by the newspapers; easy modes of making gas were described; and coal was distilled in tobacco-pipes at the fire-side all over the kingdom. . . . . But although the use of gas was thus spreading in the manufacturing towns, it made little progress in London. This may be accounted for in some measure by the circumstance that no means had as yet been found out for purifying it. It was dirty, it had a disagreeable smell, and it caused head-ache when used in close rooms."

It was then that Mr. Winsor took the matter up with a view to the removal of objections, the establishment of this as a general mode of lighting, and the founding of a joint-stock company for the purpose. He was somewhat a visionary, and failed to reap much personal advantage from the scheme; but he was a persevering man, and did much towards setting the thing afloat. The system has spread more and more every year; insomuch that the change since the commencement of the present century has been immense. At that time the "lamp-lighter" (Fig. 294) was the indispensable agent for giving not only light to kindle the lamp, but the oil and the wick which were to be kindled. At the present time a cast-iron vessel (Fig. 295) placed within a room of a building, affords to gas-companies the means of testing how the lighting of scores of streets and hundreds of shops is going on, and at what rate the light-giving agent is diffusing itself in every direction from the centre of operations.

To understand the commercial and technical machinery of this great system, it will be well to bear in mind that, in a great city such as London, there are a few establishments of great magnitude, known as "gas-works," where the invisible vapour is produced, and whence it is distributed to the surrounding districts. At each of these works the apparatus is so contrived as to lead to the desired result in a manner depending on the season of the year; much more gas being required in the winter than in the summer half-year. But whether the quantity be large or small, the steps in the process are the same. In the first place the gas is obtained from common coal, by distilling the coal in highly heated vessels closed from the access of air. The gas thus obtained is mingled with tar, ammonia, sulphuretted hydrogen, and other matters, all of which must be removed from it before it will have its proper degree of purity. This separation is brought about, first, by causing the gas to pass through cold water, whereby all the impurities which are in the gaseous form only at high temperature, are condensed: and afterwards by exposing the gas to the action of certain purifying agents which absorb the other deleterious ingredients. The gas, thus purified, passes into gasometers, from thence into a system of gauges and meters, from thence into the main pipes laid under the pavement of the streets, and lastly to the lamps where it is to be a means of diffusing a brilliant light around. This being the outline, we will next follow the successive steps a little more in detail.

In the first place, the coal which is to be used as the source for producing gas must be placed in some vessel which can be highly heated, without admitting air to act on the coal itself; because the gas, as liberated from the coal, is not to be kindled into flame, but allowed to escape from a hole in the vessel in the form of gas. The vessels employed are called "retorts," of which different forms are seen in Fig. 296. The first retort used in practice was shaped something like the bowl of a tobacco-pipe; it was an upright cylinder, having a cover at the top and a pipe by which the gas might pass out, and it held about fifteen pounds of coal. But as it was found difficult to draw out the heated coke from such a retort, after the gas had left it, another shape was devised, in which, besides the hole for putting in the coal at the top, there was another for drawing out the coke near the bottom. Another modification was, to put the coal into a kind of iron basket or grate, and to lower this grate into an upright retort, so that the coal, when changed into coke, could be removed from the retort by simply lifting out the basket. The kind permanently adopted, however, has been a horizontal retort, in which the cross section is an oval, or a circle, or an oblong square, or an arch, or some one among a great variety of forms. The mode adopted is to group five or six retorts together, and to place them horizontally in a brick-arched oven, as in the upper part of Fig. 297. The mouth of each retort projects a little from the oven; the coal is thrown in at the open mouth; and a cover being then secured on very tight, fire is applied beneath the retorts, by which the coals within them become so highly heated as to give forth gaseous matters.

The gas thus produced rises through a pipe from the upper part of the retort, as shown in the lower part of Fig. 297, and then turns down with a sudden bend till it enters a much larger pipe, called the "hydraulic main," partially filled with water. This large pipe is so arranged that all the small pipes, from a great number of retorts, dip into it, and all the gas produced in them has to pass through the liquid in the pipe before it can escape.

The gas thus produced is an impure smoky vapour, little fitted to yield the clear and brilliant light with which we are so familiar; it has therefore to pass through an ordeal whereby it may be purified. To separate the oil and the tar is no difficult matter. Even at an early stage in the history of gas-lighting this was effected by allowing the gas to ascend into a square cistern (Fig. 298) filled with water and divided with shelves; the gas, having entered the cistern, was compelled to traverse backward and forward (in the direction of the arrows) before it could escape at the top; and in the course of its passage it was well washed by the water contained in the cistern, from which the impurities were afterwards drawn off by a cock in the lower part of the vessel. This piece of apparatus is called the "condenser." Another form of condenser (Fig. 299) consists of a succession of iron tubes, through which the gas passes, and from which the impure sediment is removed by smaller tubes at the lower part of the bend.

The tar, oil, and ammonia are extracted by this means; but the gas still contains an admixture of other gases which would greatly limit its illuminating power, and the removal of which is an important matter. The most effectual mode of effecting the separation has been found to be by passing the gas through lime-water, which has an affinity for the sulphuretted hydrogen, and abstracts it from the carburetted hydrogen which is the object of the manufacture. The process is carried out by means of an apparatus such as that sketched in Fig. 300. There are three cylindrical vessels, all alike, and all containing lime-water, but all on different levels. The impure gas first enters the lowest vessel: it has to make two or three traverses before it can find its way to the pipe which leads to the middle vessel; and during this passage the lime-water is agitated by a stirrer worked by steam-power. In the lowest vessel the gas loses some of its gaseous impurities; in the middle vessel, being subjected to a second and similar ordeal, it loses a further portion; and in the uppermost it loses nearly the whole of the remainder, so as to make a tolerably near approach to a state of purity.

When purified, the gas passes along pipes to the enormous vessels called "gasometers," of which two forms are sketched in Figs. 301, 302. The various pieces of apparatus above named are represented in a more connected form in the next three cuts. In Fig. 303, for instance, is represented the interior of the retort-house of one of the great companies. The ranges of retorts are seen five in a group, and the pipes ascending from them to the hydraulic main, which runs the whole length of the building. In Fig. 304 are the condensers or purifiers, with the arrangements for admitting gas to flow *upwards* from one to another, and lime-water to flow *downwards* from one to another. In Fig. 305 we see two of the huge gasometers which occupy so striking a position in every gas-work.

The internal economy of a retort-house is very curious, since all the arrangements are so made as to waste as little material, time, and labour as possible. At one of the large London establishments the proceedings are as follow:—The empty retorts, capable of containing about three bushels each, are brought to a red heat; then a charge of coals is introduced; the cover is screwed on the end, and made tight by a cement of clay and lime. The retorts thus remain five hours, the fire beneath them being replenished with coke once every hour. By the end of this time all the gaseous products have left the coal, and have passed up from each retort into the hydraulic main. Then occurs the "drawing of the retorts:" the retort-cover is loosened by turning a screw; a slight explosion takes place (occasioned by communication with the atmosphere); the cover is removed and the coke is drawn out by means of rakes eight or ten feet long, into iron boxes, which are wheeled away, and plentifully sprinkled with water. The retorts are so divided into

groups, that some of them shall be ready for drawing every hour. Suppose that the charge of coal remains five hours in the retort; that the retorts are ranged in five groups; and that one of these groups is filled at noon; then another would be filled at one o'clock, a second at two o'clock, and the two others at three and four o'clock respectively. Then, by five o'clock the first set of retorts are ready to be "drawn;" at six o'clock the second set; and so on. Exactly as the clock strikes, the men proceed to the "drawing;" and this is continued day and night without intermission; for the gas is at all times in the course of manufacture, though not always in equal quantity.

The gasometer, into which the gas passes when quite fitted for use, is a curious piece of apparatus. So far as regards the quality of the gas, a gasometer might be dispensed with, and the gas might pass at once from the purifiers to the street-pipes. But it would be impossible to regulate the supply and pressure according to the varying demand at different hours of the day and night: a store of gas is necessary to be accumulated by that hour in the evening when so sudden and extensive a demand for artificial light occurs; and this store is kept in the gasometers. A gasometer consists of two vessels, one within another; the outer one being a tank open at the top and closed at the bottom, and the inner one being an inverted vessel open at the bottom and closed at the top. The tank is filled to a certain height with water, into which the inverted vessel dips, so that the interior of the latter is cut off from communication with the external air by the interposition of the water. Pipes pass through the water in the tank, and terminate in the vacant space within the upper vessel, by which gas is admitted. When the upper cylinder is full of gas, it rises by the ascensive power thus given to it, and forms a large reservoir, in which the gas may be contained till wanted, kept balanced by weights connected with the top of the cylinder. Such a construction is seen in Fig. 301; while Fig. 302 shows the "telescope" form of gasometer, in which there are in fact three vessels sliding one within another; the upper one closed at top and open at bottom, the lower one closed at bottom and open at top, and the middle one open both at bottom and top. It is easy to see that when empty all these cylinders fall to a level, one with another, and that when full they rise to a considerable height. As there is water to prevent any communication of air between the lower and the middle ones, so is there also water to seal up the junction between the middle and the upper ones. The gasometer sketched in Fig. 306 is a smaller but rather more elaborate piece of apparatus, employed for containing gases in many forms of chemical experiments.

A curious part of the gas apparatus is that which determines the quantity made in a given time. One of the commonest forms of meter is seen in two different positions in Figs. 307, 308, as if severed down the centre. There is externally a cylinder or drum, closed everywhere except at the centre of both sides, and near one of the edges. Withinside is another cylinder, divided into four compartments, all of which communicate by small apertures with the holes in the centre; and the inner cylinder is so connected with wheel-work behind, that if it revolves, then the wheels revolve also. The principle, then, is this:—The gas is admitted into the vessel in such a manner as to cause the inner cylinder to revolve; every complete revolution being accompanied by the passage of exactly as much gas as will once fill the inner cylinder. The ratio between the number of turns of the cylinder, and the quantity of gas which passes through it, is thus easily determined.

This measurement is further aided by a contrivance called a "tell-tale" (Fig. 309), adopted in some works. The long-hand of a clock is connected with a pencil marking on the dial of the meter; and the arrangement is such, that if no gas is made or passes through the meter within one hour, the pencil makes simply a vertical mark on the lower paper; whereas if gas *has* passed through the meter, the lower dial-face will have revolved more or less, and the pencil line will become a curve, the form and extent of which, aided by graduation on the face of the lower dial, determine the quantity of gas. At the Westminster Gas-Works, the meter is a large and elegant piece of apparatus. It is ten feet square, by seven or eight high, and is made of cast iron. All the gas made in the establishment—amounting often to considerably more than a million cubic feet in a day—passes through this meter. The meter will contain a certain known quantity, and while this quantity is passing through it, an index-hand revolves once round a dial-plate; every ten revolutions of this hand cause another index to revolve once round another dial-plate: ten of these latter revolutions cause one revolution of a third index; and so on through six successive stages, the last index revolving only once while a million cubic feet of gas are passing through the meter. By inspecting these dial-plates, then, it is easy to see how much gas has passed through the meter since the last observation; and there is also another dial for showing the *rate* or velocity at which the gas is passing at any particular moment.

In order that a supply of gas may be suitable for the varying exigences of the demand, it is necessary not only that the quantity in store be large, but that the rate of delivery should be consistent with the rapidity of the demand. As evening draws on, the demand for gas is very sudden, and if great precautions were not taken, there would be a sudden burst of light one minute, and a dim gleam the next. In order that the gas may be propelled through the main-pipes to a distance, it is necessary that it be under pressure; and this pressure has to be regulated according to circumstances. Two pieces of apparatus, "a governor" and a "pressure-gauge" (Figs. 310, 311), aid in determining these points. In the governor, the gas enters by one horizontal passage, and passes through the instrument so as to escape by another; in its transit it passes through a narrow neck at *h*, where there is a well terminated at the bottom by a kind of valve and at the top by an inverted bell-shaped vessel. Now when the gas is passing too rapidly, the bell-shaped vessel (which floats in the water, *e*) rises, and by that action closes the entrance-pipe more or less, and lessens the rapidity of entrance. It is thus a self-acting valve, like that of a steam-engine, closing or opening itself as necessity arises. The "pressure-gauge" is not self-acting: it requires the attention of men; it *indicates*, but does not *govern*, the pressure. There is a bent tube so formed as to contain water in one of its flexures; through this tube the gas passes; and the difference of the water-level in the two branches of the siphon indicates the strength of pressure, and guides the attendants in regulating it.

Lastly comes the vast underground arrangement for distributing this invaluable agent through the streets. Main-pipes of large diameter radiate in every direction from each of the gas-works; pipes of smaller diameter branch out from these to the principal streets; a kind still smaller establish communication with the minor streets; and lastly, the smallest convey the gas into the houses or up the supporting pillars of the street-lamps. The analogy which Dr. Arnott drew between the distribution of the water in the water-pipes of London and that of the blood in the human body, might be extended also to the gas-circulation:—"The supply and distribution of water in a large city, since the steam-engine was added to the apparatus, approaches closely to the perfection of Nature's own work in the circulation of blood through the animal body. From a general reservoir a few main pipes issue to the chief divisions of the town; these send suitable branches to every street, and the branches again divide from the lanes and alleys; while at last to every house a small leaden conduit rises, and if required carries its precious freight into every apartment, where it yields it at the turning of a cock." There needs but little alteration indeed to make the remark applicable to the supply of gas.

Attempts have been made to introduce *portable* gas, and also *oil*-gas, into general use; but as commercial projects they have not answered. With respect to the former, a company established a manufacture of gas, which was to be put into cylindrical vessels, and conveyed from the factory to the houses and shops of the consumers; but the enterprise failed for various causes.

The oil-gas invention was suggested by Dr. Henry of Manchester, about forty years ago, but was not actually put in operation till about fourteen years afterwards. So far as the scientific principles of the manufacture are concerned, the production of gas from oil is more simple than that from coal; but commercially it has not proved so successful. A small stream of oil is projected into a red-hot retort, partly filled with pieces of coal or coke; the oil is immediately converted into gas, which passes off through a pipe issuing from another part of the retort; and it is then cooled and collected in a gasometer. A very great diminution in the number of complex processes occurred, so as to render it much easier than the manufacture of coal-gas. But on the other hand it was found that the gas so produced could not be so sold at so cheap a price as coal-gas, owing to the greater cost of the material whence it was obtained; and this has settled the commercial part of the question. In a very small way, oil-gas is as cheap as that from coal, and much more convenient; but on a large scale the latter wholly outweighs it in advantage.

The mode of producing oil-gas may be thus simply explained. At the lower part of Fig. 312 is a retort for containing coke, into which a vertical pipe brings down oil from a reservoir above, which reservoir receives it from an oil-cistern still higher up. The gaseous product resulting from the contact of the oil with the heated coke rises up the pipe at the left hand of the figure, and passes through the oil in the reservoir; from whence it ascends by another pipe to any convenient receptacle.

Thus have we endeavoured to make the circuit of those ingenious and useful contrivances whereby man has been enabled to provide artificial light. They partake, as will have been seen, of a very wide range, from the splint of resinous pine, to the admirably conducted arrangements of gas-making; from the small earthen lamp to the splendid candelabrum; from the rushlight made by the humble peasant, to the Drummond light, calling forth a very high degree of scientific knowledge.

322.—Ancient Egyptian Dresses. (From a Painting in the British Museum.)

321.—New Zealand Dresses.

328.—Egyptian female Dresses; Working classes.

323.—Ancient Egyptian Dresses. (From the British Museum.)

327.—Egyptian male Dresses; Working classes.

325.—Chinese Husbandman's Dress.

329.—Veil of Egyptian Females.

326.—Chinese Dresses; Gentleman and Servant.

324.—Hindoo Dress.

330.—Verona, Fourteenth Century.

331.—Navarre, Sixteenth Century.

332.—French, reign of Francis I.

333.—Italy, Sixteenth Century.

334.—Verona, Fourteenth Century.

335.—Padua, Sixteenth Century.

336.—Milan, Sixteenth Century.

337.—Milan, Sixteenth Century.

338.—French, reign of Francis I.

339.—Italian Servants, Sixteenth Century.

340.—Venice, Sixteenth Century.

CHAPTER III.

THE ARTS RELATING TO THE PRODUCTION OF CLOTHING.

With the single exception of aliment, in its countless and ever-varying forms, there is no one subject which occupies an equal amount of human thought, skill, invention, industry, and capital, with that of *clothing*. It is not improbable that the correctness of this assertion may, by some, be doubted; yet a little steady consideration of what is going on around us, will show that the importance of the matter is not exaggerated.

Let us draw an imaginary line from Liverpool to Hull, across the country, and see what there presents itself. We shall find that almost the entire of the industrial arrangements, throughout a wide belt of country on either side of that line, have relation directly or indirectly to the production of clothing. The Liverpool merchants, with their docks and ships, though carrying on a vast trade in other departments, owe their wonderful commercial position mainly to the cotton trade; they being, almost exclusively, the media of interchange between the cotton-growers of the tropics and the cotton-manufacturers of England; and being also, when the crude fibres have been worked up into cloth for garments, one of the chief means of dispersing these goods over the whole globe. Proceeding thence eastward towards Manchester, what do we see? The roads, the canals, the railways, all owe their existence, to so large a degree, to cotton, that we may almost deem them part and parcel of the great system. The Liverpool and Manchester Railway would probably not have been made but for the immense traffic in cotton—raw, from west to east, and in piece-goods and yarn, from east to west—established between Manchester and Liverpool. Then, in the circle of twenty miles' diameter, having Manchester in its centre, how undeniable is the fact that the production of clothing is the very life-blood of the district! The cotton factories, with their hundreds of thousands of workpeople, are only part of the system: there must be looms, carding-engines, spinning-machines, and all the countless machinery employed directly in the manufacture, and these must have artisans to make them: there must be bleaching and dyeing and printing works, to impart a finish to that which leaves the loom in a rough state, and these in like manner must have the aid of machines calling forth the best talent of machinists: there must be steam-engines by hundreds, to give the moving power which sets all this mighty system in action; there must be builders and architects to plan and construct the vast edifices wherein these operations are carried on. Then how endless are the ramifications which spring from the main system itself! The transit from place to place gives activity, and a means of support, to carriers, coach-proprietors, canal and railway proprietors; coach and cart and waggon and boat builders. The large undertakings of the manufacturers call for the services of bankers, agents, brokers, engineers, solicitors, clerks, and others whose services are rather professional than mechanical; while the emolument earned by them, and the wages earned by workmen, give rise to a demand for the daily necessaries of life sufficient to maintain thousands of shopkeepers and dealers, both wholesale and retail: and it is in this way that we find how the population of such a district form an endless chain among them. It is true that, making an analysis in this way, it might be possible to show that a pin, a button, a book, or any other article, when its manufacturing history is traced, gives support to a large number of persons; but it is equally easy to see that, in the manufacturing districts, the mainspring which gives efficiency to all the links of the chain is the production of clothing.

When we leave the Lancashire and Cheshire district, and pass eastward to Yorkshire, we find that clothing is equally the staple on which the wealth and importance of the district depends. The wool-staplers of London, and the graziers of the midland counties, carry on a large department of trade in supplying Yorkshire with the crude materials from which cloth is to be made; while the merchants and ship-owners of Hull bring over wool from Germany, and flax from Holland, and hemp from Russia, to aid in this supply of materials. Then, the manufacturers of Yorkshire being thus supplied, they proceed to work up the diversified kinds of cloth with which we are all familiar; Halifax and Bradford take one department, Huddersfield another, Dewsbury another, while Leeds takes precedence both for the woollen and for the flax departments; and each of these towns forms a nucleus for a very hive of clothing villages. Then come all the train of subsidiary operations, arising out of the staple manufacture; from the making of a gigantic steam-engine for a flax-mill, to the serving of the little daily wants of a workman from a retail shop. The hungry mouths of the Yorkshire clothiers give prosperity to the town of Wakefield, which is the greatest corn-selling town in the North of England; and the agricultural population, for a wide range of country north and south of the clothing district, look to these clothiers as their best customers.

When we direct our glance northward to Scotland, or southward to various parts of England, we find that, though clothing may not in some instances be a prominent object of manufacture, there is no other, with the exception of food, so largely important in the whole.

If we trace an irregular line from Aberdeen, through Dundee, Perth, Stirling, and Glasgow, towards Paisley and Kilmarnock, we shall find that the inhabitants of a wide belt of country on either side of that line, derive the main part of their support, in one way or other, from the production of clothing, either in spinning flax, wool, and cotton, or in working up those materials into woven goods.

At Norwich, the bombazin and crape manufacture is larger than any other; at Northampton, the manufacture of shoes and boots takes the lead; at Newcastle-under-Lyne, the manufacture of hats is the staple; at Leicester and Loughborough, and a large number of neighbouring villages, the production of worsted hosiery and gloves is almost exclusively the source of occupation and support; at Nottingham, cotton hosiery and bobbin-net are decidedly the staple of the town; at Derby and Macclesfield, at Congleton and Leek, silk takes the lead before all other objects of attention; in a large number of towns in the counties of Cambridge, Huntingdon, Bedford, and Buckingham, the making of lace, and of plaited straw for bonnets, is, after agriculture, by far the most important occupation of the people; in a large and important part of the West of England, the making of woollen goods is the chief department of industry.

When we come to the metropolis, we find that the industrial arrangements relating to clothing apply rather to the making of garments from the woven and otherwise prepared materials, than in the manufacture of these materials themselves; and to the trading consequent on the actual sale of the garments to the wearers. But even here we find that whole districts derive their importance from clothing. Bermondsey, for example, is an extremely busy manufacturing spot, the wealth and ingenuity of whose inhabitants depend mainly on the production of hats, leather for boots, shoes, and gloves, and the collecting and sale of wool for the clothing districts. Spitalfields and Bethnal Green, again, depend more on the trade of silk-weaving than any other employment.

To follow out this matter to its fullest extent is, of course, impossible here; but sufficient has perhaps been said to show how enormously the subject of clothing absorbs the attention of the people of this country. The ships that bring over the raw materials of manufacture; the workmen who build those ships; the machinists who give the means of working, and the men who do the work; the forming of garments from the prepared materials, and the sale of the garments so formed; the transit from one part of the country to another, and the shipment to foreign countries; together with the commercial, the financial, the professional, and the legislative arrangements arising immediately from these employments—form a whole which has no parallel, except as relates to the article of food; and even this exception only applies under certain points of view.

Foreign countries do not perhaps exhibit this feature so strongly as England; but when we consider how important the culture of hemp and flax is to some of the eastern parts of Europe, silk to Italy and India, cotton to America, and other products to numerous other countries, we should perhaps find that *growth* is, to them, nearly what *manufacture* is to us, as to commercial importance. But the estimate need not be worked out with any great nicety: there is sufficient to show how large a portion of *art*, taking the word in its industrial acceptation, is applied to the production of dress; and we shall have occasion to show that art, in its higher acceptation, has also lent its aid largely towards the same object.

An interesting feature in our present chapter—introductory to the illustrations of manufacturing processes, but connected with them in relation to the materials employed at different times and by different nations—is that relating to

VARIETIES IN THE FORM AND MATERIALS OF DRESS.

There have been many attempts to establish rules of *taste* as to dress; but the strange diversity of opinion which everywhere prevails, significantly shown by that which is called "fashion," is enough to prove that the attempts have not been very successful. Why is a "dress" coat more elegant than a "frock" coat, and a black hat more general than a white one? Why did the waistcoats of our great-grandfathers reach to a length double of that which would now be deemed "becoming," and why have the nether garments changed their length in an opposite ratio? Why did the ladies of the last century think the female form more beautiful when encompassed with a hoop a yard in diameter; and if it were proper then, why is it not so now? Why were high-heeled shoes a beauty then and a vulgarity now? Why do the women of Spain pay such attention to the neat attire of their feet, and those of Normandy wear clumsy wooden shoes, and those of Hungary wear boots reaching nearly to the knee, and those of Turkey wear shoes turning up at the toes, and those of China wear such as are fit only for a doll? We might go on asking such questions without end, but should obtain very little of a satisfactory kind by way of answer. The truth is, so little has been done towards establishing a standard of taste in such matters, that fashion changes more from a desire for novelty than from anything else.

With respect to the *materials* for dress, there has been better ground for prevailing customs than in relation to *form*. Some countries are so circumstanced as to be dependent for their clothing on one particular kind of raw material, the use of which becomes a matter of necessity rather than choice; while in other countries inventions or improvements may from time to time place at the disposal of the inhabitants materials more fitted for the purpose than those before used; or commercial intercourse may lead to a more efficient exchange of such materials, mutually beneficial to the two parties engaged in the exchange.

These points we may illustrate by glancing at a few foreign countries, and, more fully, our own country in successive centuries.

Greek and Roman Dresses.

The flowing and easy robes of the inhabitants of ancient Greece and Rome have often been alluded to as the nearest approach to the perfect in respect to form of dress; but this is after all mere opinion; for when we come to consider how much *climate* has to do with the comfort of dress, we see proof that that which may be easy and elegant in one country may be insufficient in another. There is this source of connexion or similarity between the Greeks and Romans as to attire, that the latter adopted the chief habits of the former, with such variations only as appear to have depended rather on fashion than on utility.

One of the most characteristic features of costume, in the times of which we are about to speak, was the *tunic*. This was an under garment worn by the Greeks; of which there were two kinds: the one Dorian, which, as worn by males, consisted of a short woollen shirt, without sleeves; the other, the Ionian, a long linen garment with sleeves. The Dorian tunic was fastened over both shoulders by clasps or buckles, which were often of considerable size. It was joined together only on one side, the other being left open, or partially open, to give free movement to the limbs in athletic exercises. Many of the females of Greece wore a garment of this kind, often the only one. It is believed that the representations of the Amazons, found on still existing sculptures and friezes, such as some of those in the Elgin Gallery at the British Museum, show a style of dress nearly like that of the ancient Spartan females; in which the short tunic constitutes nearly the whole attire. The Ionic tunic was much more ample: it reached to the feet, had wide sleeves, and was made of linen. The sleeves were, however, generally so managed as to cover only the upper part of the arm.

Among the Romans the tunic was an under woollen garment. The toga or winter robe is said to have been the earliest Roman dress, and the tunic to have been superadded at a later period; and when the latter was first used, it was merely a short garment without sleeves. Men were deemed effeminate who wore tunics with long sleeves, and reaching to the feet. It was usually fastened round the waist with a girdle when complete; but was often loose and ungirded at

home. Numerous works of art, in sculpture and gems, represent this short Roman tunic. The tunics of the females were larger and longer than those of men, and always had sleeves, generally, however, so arranged as to cover only the upper part of the arm. Both sexes, among the Romans, commonly wore two tunics, an outer and an inner.

Besides the two tunics, the men wore a *toga* and the women a *palla*. The toga was originally worn only in Rome itself, and the use of it was forbidden to foreigners and to exiles. It seems to have been nearly of a semicircular shape, so as to arrange itself in numerous folds. It has been supposed that the mode of arranging it was somewhat as follows:—the piece of cloth, being nearly a semicircle, was held behind the back, with the curved edge downwards; one corner was thrown over the left shoulder, and the rest placed on the right shoulder and round to the front of the body, leaving very little of the chest uncovered, and hanging down nearly to the feet; the remaining end or corner was then thrown back over the left shoulder, in such a manner as to cover the greater part of the arm; by this arrangement the right arm was covered by the garment, but it was occasionally released by throwing the toga off the right shoulder, and leaving it to be supported by the left alone. Another mode of wearing the toga was to form a part of the toga itself into a girdle, by drawing its outer edge round the body and tying it in a knot at front; at the same time covering the head with another portion of the garment. A third mode was to fold the toga, and place the round edge almost close under the arm, and draw it gently across the chest to the left shoulder; while the other part was allowed to fall gracefully over the lower part of the body; the remaining end of the garment was then thrown over the left shoulder, and allowed to hang down nearly as low as the other end. The colour of these togas was generally white. Black wool togas were worn for private mourning, and also by artificers and the humble classes. Embroidered togas were worn by generals in triumphs, and by others among the higher classes. Strutt mentions in connexion with this garment, that "the toga was white, except it was used in time of mourning; it was then of a dark colour, or black. The *toga prætexta*, worn by young men of rank until they reached the age of seventeen, and by young women until they were married, was distinguished by a purple border: this dress, however, was not confined to the Roman youth; it was sometimes used by the priests and magistrates. When a young man laid aside the *toga prætexta* he assumed the manly gown called the *toga virilis;* and various ceremonies were performed with great solemnity upon the occasion; however, as a mark of modesty, during the whole of the first year, it was usual for him to keep his right arm within the folds of his gown. It was customary with candidates for public offices to appear before the people clothed with the toga only, to show their humility on the one hand, and to expose with more freedom such parts of their body as had been wounded in their country's service."

At a later period of Roman history the *toga* was superseded by the *pallium* as a general garment. This pallium was simply a rectangular piece of cloth, very nearly square. It was sometimes ornamented with fringe, and had often ornaments of various kinds, produced either in weaving or dyeing. By interweaving sprigs or flowers with the "weft" or cross threads, very elegant designs were produced; whole figures, and even historical or mythological subjects, were thus produced, forming a sort of elegant employment for the higher class of females. The embroiderers were often employed on the pallia when the latter were richly adorned, while the fullers obtained occupation in whitening those which were devoid of colour. A pallium was, among the Romans, a most useful article; for it formed not only an outer article of dress, when thrown over the back and shoulders, but was often used as a sheet, as a blanket, as a covering for beds and couches, as a carpet for the floor, as an awning or curtain over doors, as a towel, as a sail for a boat, as a shroud, and as a horse-cloth. It must not be supposed that any one piece of cloth rendered all these multifarious services; but a square piece of woven material, whether of woollen, linen, or silk, and called a pallium, was capable of being applied to any one of these uses, according to the necessities of the case. Sometimes the Romans wore a *lacerna* over the toga. This was a cloak, very little other than a mere piece of cloth, and fastened over the right shoulder by means of a buckle. It seems to have been often carried on the arm, as we now do a greatcoat, to be put on as an extra garment when the weather became more chilly.

The *stola*, which was worn by Roman females over the tunic, was a robe which fell as low as the ankles, and was fastened by a girdle at the waist: it usually had sleeves, but not always, and was fastened over the shoulder by a clasp.

Besides the above garments, which seem to have formed the main features of dress, there were many others, of which Montfaucon and other writers have given descriptions. One was the *synthesis*, a kind of loose mantle worn by the Romans at feasts, on which occasions the toga was not worn. The *tribon* was a coarse black or brown mantle, worn by some of the Greek philosophers; while the *trabea* was another and more glittering mantle, used as a dress of honour and distinction by high personages. The *chlamys* was a kind of cloak worn both by Greeks and Romans over the tunic.

With respect to the four important filamentous materials for dress—woollen, cotton, linen, and silk—the Greeks and Romans appear to have been chiefly dependent on themselves for woollens, on the Egyptians for linen, on the East Indies for silk, and to have had scarcely if any knowledge of cotton. The trade of "fuller," in connexion with the woollen manufacture, was well known at Rome. With respect to cotton, Mr. Baines remarks:—"It appears that the growth and manufacture of cotton had, at the Christian era, extended to Persia and Egypt; and also that the delicate fabrics of India, including muslins and calicoes, both plain and figured, were brought by Greek navigators to the ports of Egypt and Arabia, whence, it may be presumed, they would reach the capital of the Roman world and some of the wealthy cities of Greece. Yet cotton goods could not have been imported into Rome or Greece to any considerable extent, or even regularly, since there is no distinct mention of them as articles of importation or consumption by any of the writers of those countries, though the other produce of the East—gold, spices, precious stones, and even silk—are often specified." After commenting on the absence of evidence as to the use of cotton garments by the Greeks and Romans, this writer remarks that he can only account for the fact by supposing that the soft texture, glossy surface, and brilliant hues of silk, so different from linen, woollen, or cotton, and so much superior, attracted general attention; and that muslins and chintzes could not vie with silks as articles of luxury, whilst they were too dear to compete with the manufactures of wool and flax as the materials of ordinary wear.

There can hardly be a better idea given of the appearance of the easy and flowing drapery of the Greeks and Romans, especially the former, than by an inspection of the various specimens of ancient art contained in the British Museum. The headless and armless trunks found among the Elgin Marbles often present, with indescribable grace and ease, the loosely fitting robe and the variously formed tunic: so close is the resemblance in some cases, as in those represented in Figs. 313, 314, that it is scarcely possible to believe marble could be made so closely to imitate the textile lightness of woven materials.

The various cuts on page 73 (Figs. 313 to 320) illustrate many of the forms of dress alluded to in the above paragraphs.

Costume in Early Times generally.

We find, on comparing the Greek and Roman dresses with those of other early nations in an advanced state, that there was considerable difference between them; the former being much more simple, easy, and flowing than the latter, in most cases; less costly and brilliant in relation to ornamental trappings, but more elegant as to form.

If we could trace the proceedings of every nation up to its earliest origin, we should find the first attempts to provide clothing pretty much alike in all. The skins of animals, or the wool or hair forming the external envelope, form the first, as they are the most natural source; the interweaving of textile fibres being obviously a later step. Thus the New Zealanders (Fig. 321) may fittingly represent many other tribes in an early period of their history. The inhabitants of those islands are rapidly yielding to the improved habits and customs which the English are introducing among them; but, taking the New Zealand dress in its national form, it may be described simply as consisting of an inner mat or tunic, fastened by a girdle round the waist; and an upper cloak, plain or ornamental according to circumstances. This, however, is a more favourable specimen than many rude nations present; a species of flax grows in New Zealand, and the inhabitants have ingenuity enough to plait or weave this into a kind of cloth. The records of our travellers and voyagers afford abundant evidence that the skins of animals precede textile fibres as a material for dress; and the history of the early nations corroborates this opinion. The art, likewise, of converting these skins into leather was very early known; for the outer coverings of the Tabernacle are said to have been made from rams' skins and the skins of badgers; and as these are also spoken of as being dyed, some kind of tanning or dressing must have been carried on. Shoes and girdles, too, are often alluded to as having been made of leather.

The nations of whose early history we have any authentic account soon, however, acquired the art of weaving fibres into the form of cloth. The phrase "vestures of fine linen," used in Genesis as applied to the dress of the superior officers of Pharaoh's court, shows that weaving of fibres into cloth must have been known at a very early period. All the allusions to woven textures as worn by the Israelites seem to afford proof that Egypt took precedence of Judæa, and of all other nations then known, in that department of art, as indeed they did in most others. Mr. Strutt observes:—"The linen manufactured by the Egyptians maintained its precedence in foreign countries for many succeeding generations: it was called 'fine linen' by way of eminence, and formed a very material part of the exports of that country. From this source the Israelites certainly derived the skill in the clothing arts for which they are celebrated by Moses; and with them it seems to have declined in proportion as they receded from their task-masters. In the days of Solomon, it is true, the thread, or, as it is called, linen-yarn, was brought unworked from Egypt to Jerusalem, to make the decorations for the first temple; but, at the same time, it was necessary to call in a foreign artist to superintend the manufacturing of those materials; and he himself performed the most elaborate part of the workmanship."

It is quite evident that linen constituted a notable material for dress among the Israelites, and that there were different kinds appropriated to different purposes; for there are allusions in the Pentateuch to "fine linen," "fine trimmed linen," and "fine linen of woven work." It is known also that linen was worn by the Syrians and the Assyrians, as well as the Israelites and the Egyptians. Linen was more used than wool in those times; but the latter material was not neglected, for we find frequent allusions to its use. Heeren, in his learned 'Historical Researches' concerning the Eastern nations, after speaking of the difficulties which lie in the determination of the question how far silk and cotton were known to the ancients, thus alludes to woollens and furs:—"The finest descriptions of wool, manufactured principally in Babylonia and the Phœnician States, was the production of many parts of Asia. Herodotus himself has given us a description of the Arabian sheep, distinguishing the two sorts of which the breed is composed, that with a long and that with a broad tail. In the mountains also of northern India, the district of Belur, or the vicinity of Cashmere, were found then, as at present, large flocks of sheep, which constituted the wealth of the inhabitants; and no one acquainted with ancient history needs to be reminded of the rich fleeces of the sheep of Asia Minor, particularly those in the territory of Miletus. The Milesian wool was accounted by the Greeks the finest of all, probably because they confounded with the native fleeces of Miletus the wool of Arabia and Central Asia exported from that city. There are also abundant proofs that another branch of trade, now of great importance, that of furs, not only existed in the times of which we are speaking, but had attained considerable importance. Supposing it to have been of less importance than it is at present, the cause was not so much from want of acquaintance with the fur countries as that the temperate climates enjoyed by the then civilized nations of the world rendered this article of dress unnecessary. The Grecian colonies to the north of the Euxine formed, however, an exception to this rule. They drew supplies of peltry, the skins of the otter and beaver, from the very interior of Russia, and possibly even from the shores of the Baltic, and easily disposed of them in the neighbouring country of Thrace, the inhabitants of which were principally clothed in furs. It may be observed that the Amazons are also occasionally represented in sculpture as thus habited, or rather (which is observable) loosely arrayed in furs. The use of them would appear to be in general a matter of luxury as well as necessity, even in warm climates, as it continues to be at present among the Turks. In his account of the army of Xerxes, Herodotus enumerates several nations habited in the skins of animals; as, for instance, various tribes from the east and north-east of the Caspian Sea, the Utii, &c., as well as the inhabitants of the rugged mountainous tract on the south-east boundary of Great Bucharia, the Pactyes of Belur-land, and others."

In the early times the preparation of the materials for clothing was not, as now, a separate branch of trade carried on for profit, so much as an employment for females in the domestic circle. The dressing of flax, the carding of wool, and the processes incident to spinning and weaving, were not considered unworthy of the attention of the high-born and wealthy. The matron of a family generally superintended all such arrangements, which were carried on under her roof. There are, in the 31st chapter of Proverbs, many enumerations of the qualities of a good housewife, of which some are as follow:—"She seeketh wool and flax, and worketh willing with her hands:" "she layeth her hands to the spindle, and her hands hold the distaff:" "she is not afraid of the snow for her household, for all her household are clothed with double garments:" "she maketh herself coverings of tapestry, her clothing is of fine linen and purple:" "she maketh fine linen, and selleth it; and delivereth girdles to the merchants." This system of domestic spinning and weaving was carried on not only for the supply of the household, both male and female, with materials for dress, but for making presents to guests, and also for the sake of clothing the poor. Those departments of the manufacture which depended on the ornaments of

341.—Anglo-Saxon Dresses.

342.—Anglo-Saxon Dresses

343.—Anglo-Norman Caps and Shoes.

344.—Anglo-Norman Dresses.

345.—Reign of Edward II.

346.—Reign of Henry I.

347.—Reign of Henry III.

348.—Reign of Richard II.

349.—Reign of Edward II.

350.—Reign of Richard II.

351.—Reign of Edward III.

352.—Reign of Henry IV.

353.—Reign of Richard II.

354.—Reign of Henry IV.

355.—Reign of Henry V.

356.—Reign of Henry VI.

357.—Reign of Henry VI.

358.—Reign of Edward IV.

359.—Reign of Richard III.

360.—Reign of Henry VI.

361.—Reign of Edward IV.

362.—Reign of Henry VII.

363.—Reign of Edward VI.

clothing by embroidery, were much cultivated by the Israelites and many other nations, and seem, so far as the description can be relied on, to have been conducted with much skill.

Besides the spinning, weaving, and embroidery of clothes, there is abundant proof that *dyeing* was extensively practised by the nations of whom we are now speaking. Joseph's "coat of many colours" affords an early evidence of this. Blue, purple, and scarlet were the three chief colours of which we find mention. Purple was then, as it is now, a sort of royal colour, used by pre-eminence among the monarchs and great men: indeed a persuasion was sometimes held, that in the purple dye there was some hidden merit which appeased the wrath of the gods; and the Babylonians used to array their deities in robes of purple.

As to the form of the dresses worn by the principal nations of early times (as was remarked in the case of the Greeks and Romans), the best idea we can obtain of them is from the monuments of antiquity, containing paintings and similar representations. Among the Egyptians there is proof that the kind of dress depended on the rank of the wearer, not only for costliness but also for form. One of the classes wore two garments; the one a lined tunic, ornamented with a web or fringe at the bottom; and the other a white woollen mantle, which was thrown over the former. With regard to wool, it was a custom or law that no man could enter the places of worship with any garment made of wool, nor could he permit his relatives to be buried in the same material. In the Egyptian sculptures and paintings deposited in the British Museum (of which two specimens are given in Figs. 322, 323), there is everywhere observable the use of very tight-fitting dresses, supposed to have been principally of linen; and the intermixture of colours was also very profuse. In some specimens there is seen a *pectoral* or covering for the chest made of plaited and folded linen. In others there are two broad straps, passing over both the shoulders, and crossing each other in front, where they are fastened with a girdle. Various other forms are met with; but in very few instances is there any part of the Egyptian dress bearing analogy to the flowing robes of other nations. Sir J. G. Wilkinson ('Ancient Egyptians') remarks that the quantity of linen manufactured and used by the Egyptians was surprisingly large; since, independent of that used for the common articles of dress, the whole of their mummies were wrapped in linen dresses. There were restrictions in force against the priesthood wearing either cotton or woollen in their temples, linen being the prescribed material. "Whatever restrictions may have been in force," he observes, "respecting the use of cotton among the priesthood, it is probable that other individuals were permitted to consult their own choice on this point; and it was immaterial whether they preferred during life the coolness of flax or the softness of cotton raiment, provided the body after death was enveloped in bandages of linen; and this regulation accounts for the mummy-clothes of the poorest individuals being invariably found of that material."

The most material feature in the ancient Jewish habit was the *tunic*, girded round the body; it reached to the ankles, fitted very close to the body, and had straight sleeves. Those made for the priests and for persons of distinction were of "fine linen;" coarser materials were employed for the tunics of the middle and humble classes, sometimes consisting of a mixture of cotton and wool; but there were examples pointed out in which the use of the mixed material was forbidden. Beneath the tunic was frequently, perhaps generally, worn a kind of shirt made of linen; and outside the tunic was a mantle, depending for its material and appearance on the rank of the wearer. Josephus says that the mantle, or super-tunic, was not composed of separate pieces, but was one long garment woven throughout without seams, with an aperture at the neck lengthwise from the breast to the middle of the back; and that the selvages were bound with a ribbon to give a handsome appearance to the opening. The dress of the Jewish females, as elucidated by many passages in Scripture, seems to have been remarkable rather for its splendour of decoration, than for any peculiarity of form, colour, or material.

It has been remarked, in relation to the Philistines and other nations contiguous to Judæa, that there is a passage in the Book of Judges, seeming to imply that the main articles of dress in common use did not differ materially from those of the Israelites. When Samson had lost "thirty shirts and thirty changes of raiment," which he had promised to the Philistines upon the explication of his riddle, he slew thirty men of Askelon and took their shirts and their changes of raiment, which he gave to the men who had expounded the riddle, without any notice being taken of the fact that they belonged to people of another nation.

With respect to others of the early nations, it is not difficult to see that their style and materials of dress must have approached more or less closely to one of these forms:—the rude and barbarous habits (adopted by nations scarcely advanced at all in the arts of life) made of skins of animals more or less prepared, or of plaited reeds and fibres, and among whom the tattooing of the skin was almost as great a point in personal decoration as the production of any kind of garments; the comparative close-fitting and coarse woollen or leather garments, of which we shall have to speak in connexion with early English dress; the easy and flowing garments of linen, woollen, or silk, worn generally by the Greeks and Romans, and partially by some others of the early nations; or the gorgeously decorated dresses of those eastern nations, among whom the splendid colours of the silk, and the costly adornments of jewels, were more notable points than the actual form of the garments themselves.

This brings us to the subject of

Oriental Dress in the present Day.

Customs change so slowly in the East, that there are many nations and tribes among whom the same form of garments, and made of the same materials, are worn now as were worn ages ago; although, in other instances, increased facilities for the manufacture or the purchase of particular materials for dress have wrought some changes. With regard to Oriental dress generally, it is observable that it bears no resemblance whatever to ours, and is in all respects more ample and voluminous, allowing greater freedom of motion and exertion. The turban is a much more elegant and convenient head-dress than a hat; and being susceptible of great variety in form, colour, and arrangement, discovers at the first glance the differences of nations and ranks. As the neck and limbs are not confined by bandages or ligatures, a native of the East may remain a month in his clothes without feeling fatigued by them.

In India we find, that while cotton and silk are the great staple materials of dress, the utmost diversity of form exists among the garments worn by different tribes and nations, varying from an almost utter absence of clothes to an accumulation of ample robes, sashes, and trowsers. The "Serpent-charmer" (Fig. 324) is not a bad illustration of a large class of Hindoos, among whom the bare limbs and the turbaned head are very prevalent. This is the general attire of the Chandalas, a caste of Hindoos whose office it is to bury the dead; but whose turban has a particular form, not adopted by the other castes. The Brahmins wear as their only garment a long loose cotton gown or robe, reaching to the ankles; the head having neither turban nor hair on it. The Bheels, a slight but elegantly-formed race, have cotton turbans and drawers, and a cotton shawl thrown over the left shoulder. The Scindians are amply clothed to the feet, with a closely-fitting kind of sleeved tunic, a robe or mantle over this reaching down to the feet and a wide-spreading turban. The Mahrattas leave the leg bare from the knees downwards, but are clothed from thence upwards in a tolerably close dress, bandaged round the waist with a shawl, and having the head covered with a turban of peculiar shape. The Coolies, whose transportation to the sugar-estates of the West Indies has lately occupied public attention, have a very scanty dress, similar to that of the Bheels. The Seiks wear trowsers, approaching in shape to those of Europe, together with a close-fitting jacket, a shawl thrown over this, and a kind of cap on the head instead of a turban. The inhabitants of Cutch wear trowsers gathered in at the ankles, a dress having a tightly-fitting body and sleeves, with a loose flowing skirt, a shawl round the waist, and a large turban. The Rajpoots are a warlike race, whose dress bears not an unapt resemblance to that of the Crusaders in past ages, being formed to serve not only as dress, but as a protection in war. The Rohillas wear a loose robe reaching nearly to the feet, bound round the waist with a silken sash, and have also trowsers reaching to the ankles, and a turban.

In all these varieties of Indian costumes, cotton is a more prevalent material than any other. India was the birth-place of cotton and the cotton manufacture. Its natives can spin and weave much more delicately than any other people, as far as the work of the hand is concerned. It has been supposed that cotton was known and worn in India as early as linen was in Egypt; but the evidence on this point must necessarily be very vague. Silk is also largely manufactured and worn in India; and in the north-western provinces, near Cashmere and Thibet, a kind of wool produced from peculiar species of goats and sheep is largely manufactured into shawls and turbans.

Turning now to a more eastern country, China, we find that silk is there the staple material for dress. The Chinese mode of dress generally is thus described by Mr. Davis:—"The summer garment of the better classes is a long loose gown of light silk, gauze, or linen, hanging free at ordinary times, but on occasions of dress gathered in round the middle by a girdle of strong wrought silk, which is fastened in front by a clasp of agate, or of the *jade*, which the Chinese call *yu*. In an oppressive climate, where the thermometer is at 80° or 90°, there is much ease and comfort in the loose sleeves, and the freedom from restraint about the neck by which this dress is distinguished; and the tight sleeves and huge collars of Europeans very naturally make them objects of compassion, if not ridicule. . . . . The winter dress, being nearly as loose as that of summer, is less calculated to promote warmth and comfort than the European costume, and at the same time more unfavourable to bodily activity and exertion. Over a large dress of silk or crape, which reaches to the ankles, they wear a large-sleeved spencer, called *ma-kwa* (a riding-coat), which does not descend below the hips. This is often entirely of fur, but sometimes of silk or broad-cloth, lined with skins. The neck, which in summer is left quite bare, is protected in winter with a narrow collar of silk or fur; their loose dresses always fold over to the right breast, where they are fastened from top to bottom, at intervals of a few inches, by gilt or crystal buttons (the latter in mourning) with loops. In summer the nether garment is loose, and not unlike ancient Dutch breeches; but in winter an indescribable pair of tight leggings are drawn on separately over all, and fastened up to the sides of the person, leaving the voluminous article of dress above mentioned to hang out behind in a manner that is anything but pleasant. Stockings of cotton or silk, wove and not knit, are worn by all who can afford them; and, in winter, persons of a certain rank wear boots of cloth, satin, or velvet, with the usual thick white sole, which is *kept clean by whiting* instead of *blacking*, in the usual style of contrariety to our customs. The thick soles of their boots and shoes in all probability arose from the circumstance of their not possessing such a substance as well-tanned leather, a thinner layer of which is sufficient to exclude the wet. The shoes made for Europeans at Canton are perfectly useless in rainy weather, and spoiled on the very first wetting."

We learn from the same authority that the ordinary female dress in China is a large-sleeved robe of silk, or of cotton among the poorer classes, over an inner garment, sometimes of a pink colour; under which are loose trowsers fastened round the ankle, just above the shoe.

The ordinary dress of men among the working classes consists usually in summer of a pair of loose cotton trowsers tied round the middle, and a loose shirt or smock hanging over it: in very hot weather the smock is thrown off altogether, and only the trowsers retained. Some of the husbandmen have scarcely any garments on their lower limbs in summer; they defend the head from the heat of the sun (Fig. 325) by a very broad umbrella-shaped hat made of plaited bamboo slips; which, in winter, is exchanged for a felt cap. In rainy weather they have cloaks made of a species of flag or reed, from which the water freely runs off. The use of skins in dress is very general. The lower orders use those of the sheep, cat, dog, goat, squirrel, rat, and mouse, sewn together for garments in winter weather. The higher classes have expensive fur dresses which descend from father to son, and often form a considerable portion of the family inheritance. "At an entertainment in Canton, where the party, according to the custom of the country, were seated in an open room without fires, the European guests began to complain of cold; upon which the host immediately accommodated the whole number of ten or twelve with handsome wide-sleeved spencers, all of the most costly furs, telling them at the same time that he had plenty more in reserve." Fig. 326 shows the costume of two persons of different rank in society.

The customary dress of the Chinese is evidently very much dependent for its character on the extensive rearing of the silkworm in that country; since the facility with which silk receives brilliant colours, and the peculiarity of its texture when woven into piece-goods, modify of necessity the general effect of the garments from it. In Egypt, on the other hand, the bulk of the population, in present times as well as the past, employ much more cotton, linen, and woollen than silk; and the attire is for the most part very differently formed from that of the Chinese. A few particulars collected from Mr. Lane's work on the 'Modern Egyptians' will illustrate the general character of the dress of that people.

Men's dresses, among the higher and middle classes, consist, first, of a pair of full linen or cotton drawers, tied round the body by a running string or band, the ends of which are embroidered with coloured silk: they descend a little below the knees, or near the ankles. Next is worn a shirt, with very full sleeves reaching to the wrist; it is a white, open-textured garment, made of cotton, of muslin, of silk, or of two or three combined. Over this in cool weather is generally worn a sort of short vest without sleeves; and over this a longer vest descending to the ankles; the sleeves extend below the fingers, but are so shaped as either to cover or conceal the hand at pleasure. An outer robe is also often worn, with sleeves reaching nearly to the wrist. These vests and robes are made of all the four materials—cotton, linen, woollen, and silk—variously combined; but the outer one is mostly woollen. On the head is worn a small close-fitting cap; next another cap of red cloth; and lastly a long slip of fine muslin bound round the head in the form of a turban. Stockings are not used; but some few persons in cold weather wear woollen and cotton socks. The shoes are of thick red morocco, pointed and turned

up at the toes; sometimes inner shoes of soft yellow morocco are also worn.

The Egyptians of a humbler class (Fig. 327) have a much simpler dress. The shirt is made of blue or brown linen, cotton, or woollen, open from the neck nearly to the waist, and having wide sleeves; and this, with the drawers underneath, often constitutes the whole of the dress, with the exception of turbans and shoes. The turban is generally composed of a white, red, or yellow woollen shawl, or a piece of coarse cotton or muslin, wound round a cap. Some are too poor to have any garment besides a brown woollen shirt, while others are enabled to have a vest under it. The full sleeves of the shirt are sometimes drawn up by means of cords, which pass round each shoulder and cross behind, where they are tied in a knot. In cold weather coarse woollen cloaks or robes are often worn by those a little removed from the lowest grade.

The females of the upper ranks wear a costume which, so far as regards in-door custom, is not deficient in elegance; but the walking and riding dresses are rather singular than becoming. In general dress, over a pair of coloured silk or cotton trowsers, and a long kind of tunic of the same material, the Egyptian ladies wear a long vest, reaching nearly to the ground. A square shawl or embroidered kerchief is wrapped round the waist by way of girdle; and an outer robe, reaching to the ground, is thrown over all. But when a lady walks or rides in the open street, she puts on a strange disguise. In addition to her other garments she wears a large loose dress, the sleeves of which are immensely wide. Over this is put the *boor'cko'*, or face-veil, which is a long strip of white muslin, concealing the whole of the face except the eyes, and reaching down nearly to the feet. It is suspended at the top by a narrow band, which passes up the forehead, and which is sewed, as are also the two upper corners of the veil, to a band that is tied round the head. Enveloping the whole is thrown on a very full black silk cloak, having a hood to cover the head and forehead, and falling around the person down to the ground. The effect of this dress is that every vestige of the figure is concealed, except a pair of large piercing and brilliant black eyes, appearing beneath the hood, but above the veil (which covers the nose).

The group of women of the humbler class, sketched in Fig. 328, while they illustrate the general dress of that class, also show one of the forms of this singular kind of veil. These women wear trowsers of plain white cotton or linen, a blue linen or cotton shirt or tunic, a gown or robe of a kind of coarse black crape, and a dark blue covering for the head. The *boor'cko'* or face-veil is black. In Fig. 329 are four representations of this characteristic kind of veil, to show the mode in which it is fastened to the head. Mr. Lane says:—"The best kind of shoes worn by the females of the lower orders are of red morocco, turned up, but round, at the toes. The *boor'cko'* and shoes are most common in Cairo, and also worn by many of the women throughout Lower Egypt; but in Upper Egypt the *boor'cko'* is very seldom seen, and shoes are scarcely less uncommon. To supply the place of the former, when necessary, a portion of the *tar'hhah* (cloak) is drawn before the face, so as to conceal nearly all the countenance excepting one eye. Many of the women of the lower orders, even in the metropolis, never conceal their faces. Throughout the greater part of Egypt, the most common dress of the women merely consists of the blue shirt or *to'b* and *tar'hhah*. In the southern parts of Upper Egypt, chiefly above Ak'hmee'm, most of the women envelope themselves in a large piece of dark brown woollen stuff (called a *hhoolalee'yeh*), wrapping it round the body, and attaching the upper parts together over each shoulder; and a piece of the same they use as a *tar'hhah*. This dull dress, though picturesque, is almost as disguising as the blue tinge which, as I have before mentioned, the women in these parts of Egypt impart to their lips."

Taking China, India, and Egypt as representatives of Eastern countries generally, we shall find that the costume of other parts of the East usually presents some modification of, or medium between, these three. The Persians employ much more woollen and silk than cotton and linen in their attire. The cap, especially, is a remarkable part of Persian dress, being formed of a kind of felt or wool, and shaped almost conically: the body-dress fits very closely, and there are almost invariably wide and loose skirts to the lower part of it. The Arabs of the Desert, or at least some of those who roam along the northern part of Africa, wear a strange kind of head-dress of linen or cotton covering nearly their whole head. Those of the Arabian towns, such as in Yemen, wear caps of cloth or cotton; and Niebuhr says that an Arabian of distinction, when about to make or receive a visit of ceremony, sometimes wears as many as fifteen caps one over another, as it is considered to be an indication of wealth or distinction to have an enormous covering for the head—all the caps, except one or two, being taken off within doors. Before we laugh at such a fashion, which we might perhaps be fain to do, it would be well to think whether there are not examples quite as absurd noticeable every day in our own country.

The Turks are in a state of transition as to dress. They have begun to lessen the use of the wide trowsers, the flowing robes, the bulky turbans, and the bright silken shawls, and to adopt the sober broad-cloth of more northern countries. The late sultan began this change by introducing it into the army: time will show how far ancient usages will bear up against such innovations.

Continental Dress, at different times.

Without dwelling longer on the picturesque dresses of Eastern countries, we may glance round next at countries near home.

The first fact observable here is that the use of woollen cloth is more extensive than of any other material for dress, and more than in Eastern districts generally. As both long and short woolled sheep have been reared in most parts of Europe for ages, and as silk and cotton can only be reared, if at all, in the extreme southern parts, the inhabitants of Europe have had abundant reason for the selection of woollen garments as the chief part of their dress.

It is not among the great and high-born that we are to look for national characteristics in dress: they can afford to purchase the luxuries (or whatever may by the caprice of fashion be deemed luxuries at any particular time) of dress, from whatever quarter they proceed, and are thus less dependent on the peculiar state of the textile arts in the country where they live, than are the bulk of the people. If, then, fixing our attention on the middle ranks of society, we glance from country to country, we find that two circumstances —climate and the state of the arts relating to clothing —principally determine the kind of dress worn; the material, nevertheless, being much more frequently woollen than anything else. The woollen manufacture was early established in Flanders; and we find, in the pictures of Teniers and Ostade, abundant proof that the dress of the Flemings two or three centuries ago consisted almost universally of coarse woollen cloth. Although it is conjectured that the inhabitants of England wove woollen cloth for their own use in early times, yet there is scarcely any distinct mention of the matter until the year 1111, when some Flemings, obliged to quit their own country by an encroachment of the sea, sought refuge in England, where they were stationed in some of the northern counties. The statement itself, whatever it may indicate as to the previous state of the clothing arts in England, seems at least to imply that the Flemings were a-head of us in the preparation and weaving of woollen clothes. The Flemish and Dutch dresses have, for centuries, as a general rule, consisted mainly of a pair of most capacious ("small-clothes" we can hardly with consistency call them, but) breeches, and over these (among the working classes) a kind of jacket; but a coat decorated with rows of buttons, among the burghers and middle classes.

The Slavonian portion of the inhabitants of Europe, from Russia in the north to Hungary in the south, so far present an appearance in common, that the coat, the cap, and the boots, have a strong family resemblance. Whether the word "polka" will always suggest to English ears the same ideas as it has for the last year or two, it will certainly at present serve very well to convey a notion of the style of costume to which allusion is here made. The close-fitting tunic or coat, trimmed with fur if the climate be cold, and with showy trappings if the wearer be rich; the leather boots reaching nearly to the knee, drawn over tight pantaloons in Hungary, and loose ones in Russia; the square-crowned cap—all belong to what (if we may coin a compound term) may be called the Russo-Hungarian costume. It is observable, also, in the countries now under notice, that the female dress bears a closer resemblance to that of men than in most other parts of Europe. Throughout these countries, too, woollen cloth is the staple material from which the garments are made.

When we next glance at the costume of Italy and Spain we find changes arising in great part out of the warmer and more sunny climate of those regions. The silk-worm can flourish there; and in many of the provinces garments made of woollen cloth would be too warm to be worn with comfort. Hence we find that, at the times when the English and the Flemings were clothed mainly in woollen dresses, the inhabitants of Spain and Italy of an equal rank in society displayed a gayer attire of silk, dyed with brighter colours, than the woollens of the north. Spain, however, is in a condition to produce excellent woollens, if the social condition of the people were sufficiently settled and industrious; and indeed "Spanish cloth" has for a long time had a reputation for fineness of quality, and in the hilly districts the wearing of woollen garments is necessary; so that we might suppose this department of industry to be in a flourishing state in Spain. But such is by no means the case. Mr. Bischoff remarks:—"Spain and Portugal, once so celebrated for their woollen manufactures and their extended commerce, lost them by the pride and ambition of their grandees, who were satisfied to see foreigners purchase the produce of their flocks, and despised their home manufacturers as classes inferior to themselves, and whose attention and ambition were also withdrawn from the sober and plodding pursuits of industry, and devoted to their conquests and their mines in North America."

It is observable that in past ages, subsequent to the time of the Crusaders, and anterior to what may be termed modern times, there was not strictly a *national* costume in France or Italy, as distinguished from England. So far as we can judge from plates of costume yet existing, the dresses prevalent in the times of our Henrys and Edwards were as diversified and as picturesque as those of continental nations—a statement which can hardly be made at the present day, in relation at least to men's clothing. If we look at the cuts in page 77 (Figs. 330 to 340), most of which represent Italian dresses of the fifteenth or sixteenth centuries, we shall find that however they may differ from our present notions of dress, most of them bear a good deal of resemblance to English and French dresses of the period. There was a work published in Italy, about the time when Elizabeth reigned in England, on the subject of ancient and modern costume; it was by Cesare Vecellio, the brother of Titian, the painter; and in it are given descriptions of the prevailing costumes in Italy at and about that period. Many of them are very rich; but the dresses of persons of equal rank in England were not less diversified. From his work we learn that Italian gentlemen at that time often wore a coat or cassock, short in the waist, and reaching to the knee, having sleeves down to the elbow, and from thence showing the arm covered only by the sleeve, waistband, and ruffle of the shirt. As to the lower garments, our term "hose" does not convey the same idea as it did then. There used often to be worn pantaloons which fitted so tightly and descended so low as to serve likewise as stockings; but when the garment was separated into two near the knee, the name of "upper hose" or "upper stocks" was given to the breeches, while "lower hose" became the name of what are now stockings or hose with us. "Slashed" hose, gartered both above and below the knee with fillets of silk, were a favourite feature in dress at that time. One of the cuts (Fig. 330) represents a style of attire having something very distinctive about it: it was a Veronese dress in the fourteenth century, and was worn by ladies, and also by the elder and more staid among the male population. Younger men are believed to have worn a gayer dress, such as that in Fig. 334.

Novelties, or "new fashions" of dress, in the present day, seem to originate mainly in Paris, and to radiate thence to the neighbouring countries; but in the times of which we have been speaking, they are said to have had their birth for the most part in Italy, and to have travelled through Paris towards England. A succession of English dresses will show most of those which have prevailed on the Continent, either at the same or at a little earlier period; and we will therefore now turn our attention towards home, and see what were the forms and the material of English dress in past times.

English Dress, before the Sixteenth Century.

The Anglo-Saxons seem to have made tolerable progress in the clothing arts. Aldhelm, a bishop in the seventh century, used a simile, which implies a familiar knowledge of such subjects as if they were part and parcel of every-day occupation. He says:—"It is not the web of one uniform colour and texture, without any variety of figures, that pleases the eye and appears beautiful; but one that is woven by shuttles filled with threads of purple and various other colours, flying from side to side, and forming variety of figures and images in different compartments with admirable art." This, it is clear, relates not simply to weaving in its plain state, but to the more complicated figure-weaving, in which different coloured threads are used in the weft. There is, indeed, evidence of various kinds that this people were acquainted with the dressing and spinning of flax, and the process of dyeing; and there is presumptive evidence that they also carried on the woollen manufacture.

Among the garments worn by the Anglo-Saxons was the *tunic*, bearing a good deal of resemblance to the ancient Roman tunic. The aperture at the top was sometimes only large enough to admit the head, but was in other instances enlarged so as to be open in front. It was also, in many cases, open from the hips downward on either side, so as to give full liberty to the limbs. It rarely descended below the knee. On persons of superior quality the tunic was bordered at the edges with embroidery and coloured weaving. This short tunic (Fig. 341) was a garment worn by all classes, from the slave to the monarch; and Strutt offers a suggestion that the garments so commonly worn by rustics in all parts of England in later times, under the denomination of a "smock-frock," the collars and wristbands of which are often fancifully worked, is a descendant of the Anglo-Saxon time, with no greater change than might naturally be looked for in the difference of period.

A longer tunic was sometimes worn, by those of superior station, bound about the waist with a girdle, and descending in loose graceful folds to the ankles. The *surcoat*, worn over the tunic, was also a dress

364.—Reign of Henry VII.

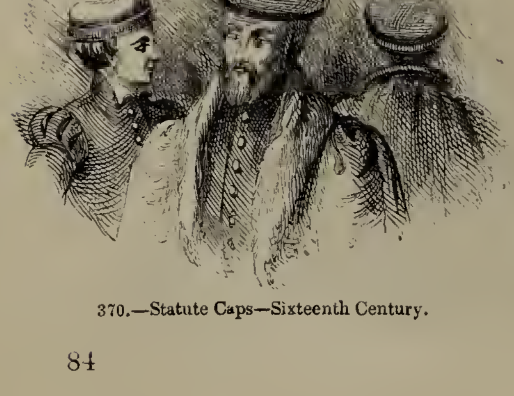
365. —Reign of Henry VII.

366.—Reign of Henry VII.

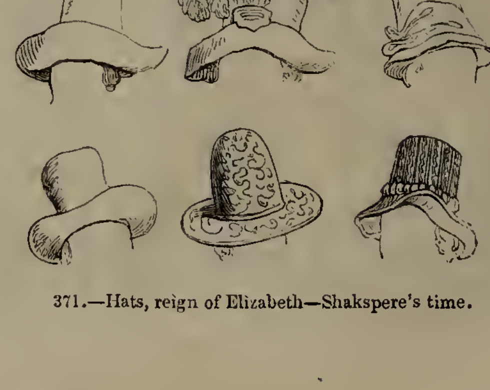
367.—Reign of Henry VIII.

369.—Reign of Edward VI.

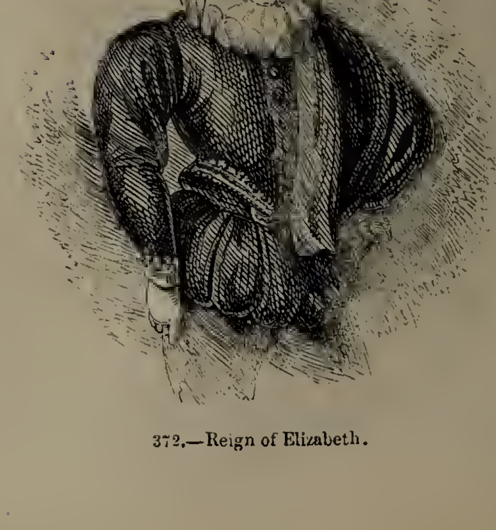
368.—Reign of Edward VI.



370.—Statute Caps—Sixteenth Century.



371.—Hats, reign of Elizabeth—Shakspere's time.



372.—Reign of Elizabeth.

373.—Reign of Elizabeth.

374.—Pedler.—Shakspere's time.

375.—Reign of Elizabeth.

376.—Reign of James I.

377.—Reign of James I.

378.—Reign of James I.

381.—Reign of James II.

379.—Reign of Charles II.

383.—Reign of William III.

382.—Reign of William and Mary.

380.—Reign of Charles II.

peculiar to the higher classes. The sleeves were large and open, descending only to the elbow; and the garment was often highly decorated. The *mantle* was another outer covering, very much varied in form and size, as depicted in the illuminations of manuscripts. It was generally fastened with a buckle upon the right shoulder, whence it descended a little below the skirts of the shorter tunic: it covered all the back, and was gathered into sloping folds over the left arm and part of the breast. The "upper" and "lower" hose, lately alluded to, were worn by the Anglo-Saxons, or at least drawers and stockings, which answered the same end; over the stockings were often bands of cloth, linen, or leather, commencing at the ankle and terminating a little below the knee, arranged in an ornamental form; while in other drawings are to be seen a kind of half-stocking or sock, worn over the larger hose.

The Anglo-Saxon females (Fig. 342) wore an attire bearing much more resemblance to that of our own time than that of their husbands and fathers. Mr. Planché (in his interesting 'History of British Costume,' to which we shall frequently have recourse in these details) says that they "wore long loose garments reaching to the ground, distinguished in various documents by the names of the tunic, the *gunna* or gown, the *cyrtle* or kirtle, and the mantle. The first and last articles describe themselves; but the terms gown and kirtle have caused much disputation, from the capricious application of them to different parts of dress. The British gown, Latinized *gaunacum* by Varro, we have already seen was a short tunic with sleeves reaching only to the elbows, and worn over the long tunic. And that the Saxon gunna was sometimes short, we have the authority of a bishop of Winchester, who sends as a present a 'short gunna sewed in our manner.' Now there is also authority sufficient to prove that a similar description of vestment was called a kirtle. No short tunics are, however, visible in Saxon illuminations, and we must therefore presume the gunna or gown generally means the long full robe, with loose sleeves worn over the tunic; and the kirtle an *inner* garment, at this period, as we find it mentioned in the will of Wynfloeda among 'other linen web; and in one place described as white. The sleeves of the tunic, reaching in close rolls to the wrist, like those of the men, are generally confined there by a bracelet, or terminate with a rich border, and the mantle hangs down before and behind, covering the whole figure, except when looped up by the lifted arms, when it forms a point or festoon in front like the ancient chasuble of the priesthood. The head-dress of all classes is a veil or long piece of linen or silk wrapped round the head and neck. This part of their attire is exceedingly unbecoming in the illumination, in a great measure probably from want of skill in the artist; for no doubt it was capable of as graceful an arrangement as the Spanish mantilla."

When the Normans came over, they wrought a gradual change in dress, as in other matters; but the change developed itself slowly. The civil costume of the Anglo-Normans so far resembled that of the Anglo-Saxons as to consist generally of a short tunic, hose, long stockings or pantaloons with feet, a cloak, shoes, and leg bandages, and a small cap or coif, as a head covering. The female attire, too (Fig. 344), bore a good deal of resemblance to that of their predecessors, exhibiting the long tunic, the *gunna* or gown, the kerchief, "couvre-chef," or head-veil. Many of the females, of both races, are represented with a kind of gloves or mufflers on their hands, having a thumb, but no separate fingers. Cloth and linen of home manufacture, and silk of foreign importation, were the materials of the dresses (cotton being unknown, or nearly so, in England until a much later period), and red, blue, and green seem to have been the favourite colours, to judge from the illuminations on the ancient manuscripts.

By about the reign of Henry I. such caps and shoes were introduced as are sketched in Fig. 343. Instead of the pantaloon-stockings and shoes, many began to wear a kind of short boot. The short tunic was made longer and fuller than before; and the long tunic often trailed upon the ground, with sleeves so long as to cover the whole hand. Shoes with peaked toes came into vogue; and sedate persons cried out (as sedate persons have often done since) against the shameful innovations in dress. During the greater part of the thirteenth century, the general male costume comprised the tunic, the cyclas, the long stockings and drawers, mantles and over-alls for travelling, long-toed shoes and boots, and small caps and coifs for the head. The female attire exhibits some curious varieties. During the reign of Henry I. there seems to have been a rage for lengthening the garments to an extravagant excess. In Fig. 346 *a* and *b* show two females with sleeves reaching nearly to the ground, *c* is a sleeve shown separately, and *d* the border of a tunic. The sleeves had often to be tied up in knots, to prevent their trailing on the ground. By the time of Henry III. a favourable change took place. The robe or gown (Fig. 347), both in the sleeves and in its general form, was much more elegant than before; and round the neck was worn a singular kind of kerchief called a gorget. There is a poem of this period, called the 'Squier of Low Degree,' in which a father, addressing his daughter, alludes to "damask" and "diaper" as being kinds of woven materials then well known:—

> "To-morrow ye shall yn hunting fare,
> And yede, my daughter, in a chare;
> Yt shall be covered with velvet red,
> And clothes of fine gold all about your head;
> With damask white and azure blewe
> Well diappered with lilies new;
> Your mantle of riche degree.
> Purple pall and ermyne free."

The coverings for the head and neck (Figs. 345, 349) were, in Edward II.'s time, rather singular, especially the gorget worn round the throat; but, by the time of Richard II., the female costume had in many particulars undergone a change (Fig. 348). Ladies then wore a kind of waistcoat or spencer-like vest, called a "cote-hardie," and the whole dress showed a change from the previous kind of costume. There is a French MS. extant, quoted by Mr. Planché, in which the cote-hardie is made to bear a part in a tale of "brave knights and fair ladies." "The eldest of two sisters was promised by her father to a young knight possessed of a large estate. The day was appointed for the gentleman to make his visit, he not having as yet seen either of them; and the ladies were informed of his coming, that they might be prepared to receive him. The affianced bride, who was the handsomer of the two, being desirous to show her elegant shape and slender waist to the best advantage, clothed herself in a cote-hardie, which sat very strait and close upon her, without any lining or facing of fur, though it was in winter and exceedingly cold. The consequence was, that she appeared pale and miserable, like one perishing with the severity of the weather; while her sister, who, regardless of her shape, attired herself rationally with silk garments lined with fur, looked warm and healthy, and ruddy as a rose. The young knight was fascinated by her who had the least beauty, and the most prudence; and having obtained the father's consent to the change, left the mortified sister to shiver in single blessedness."

Of the successive changes of dress during the next four generations, the wood-cuts (Figs. 350 to 370) will convey a better idea than any detailed descriptions. This will all the more suffice, because our object is not so much to trace the varieties of dress in respect to *form*, as to material and manufacture. We find in Fig. 360 the use of strange-shaped hats and still more strangely formed peaked toes to the shoes; in Fig. 358 close-fitting jerkins and pantaloons; in Fig. 362 a flowing robe and a square-cornered hat or cap. Those cuts representing female costume, too, are not wanting in indications of change—sufficiently extravagant so far as regards any good reason for them, but not much more so than many of later date. All kinds of ridicule and satire were occasionally levelled at the enormities in dress, of which examples are to be met with in the old chroniclers and ballad writers. The "steeple" head-dress of the ladies in the time of Edward IV. was made the subject of a pleasant paper in the 'Spectator' by Addison, who, following the account by Paradin, an old French writer, says:—"The women might possibly have carried this Gothic building much higher, had not a famous monk, Thomas Conecte by name, attacked it with great zeal and resolution. This holy man travelled from place to place to preach down this monstrous commode; and succeeded so well in it, that as the magicians sacrificed their books to the flames upon the preaching of an apostle, many of the women threw down their head-dresses in the middle of his sermon, and made a bonfire of them within sight of the pulpit. He was so renowned, as well for the sanctity of his life as his manner of preaching, that he had often a congregation of twenty thousand people, the men placing themselves on the one side of his pulpit, and the women on the other, that appeared (to use the similitude of an ingenious writer) like a forest of cedars with their heads reaching to the clouds. He so warned and animated the people against this monstrous ornament, that it lay under a kind of persecution, and, whenever it appeared in public, was pelted down by the rabble, who flung stones at the persons who wore it. But notwithstanding this prodigy vanished while the preacher was among them, it began to appear again some months after his departure; or, to tell it in Monsieur Paradin's own words—"the women that, like snails in a fright, had drawn in their horns, shot them out again as soon as the danger was over."

Sumptuary Laws of the Fourteenth, Fifteenth, and Sixteenth Centuries.

Not only is the word "sumptuary" almost unused in the present day, but the meaning attached to it could hardly be conceived by many persons. If any one now-a-days can pay honestly for a superfine cloth coat or a silk dress (we omit mention of those who cannot), he or she would have very little disposition to ask for permission so to do. Yet there was a time—and this often repeated—when the sovereign intermeddled in such matters, and attempted to lay down rules as to what classes of persons should wear a certain style of dress. It is true that the wearers showed very little disposition to respect these orders; but the orders are nevertheless instructive, because they were founded in many instances on considerations (erroneous, perhaps) connected with the state of the textile manufactures: sometimes the scarcity and expense of imported silk; sometimes the desire to foster the woollen manufacture; and sometimes the wish to render England independent of foreign supplies.

In the year 1363 a complaint was made in parliament against the general use of expensive apparel, not suited either to the degree or the income of the people; and a law was consequently passed, imposing restriction in this matter:—Furs of ermine and lettice, and embellishments of pearls, excepting for a head-dress, were strictly forbidden to any but the royal family, and nobles possessing upwards of one thousand pounds per annum. Cloths of gold and silver, and habits embroidered with jewellery, lined with pure miniver and other expensive furs, were permitted only to knights and ladies whose incomes exceeded four hundred marks yearly. Knights whose incomes exceeded two hundred marks, or squires possessing two hundred pounds in lands or tenements, were permitted to wear cloth of silver, with ribands, girdles, &c., reasonably embellished with silver, and woollen cloth of the value of six marks the whole piece; but all persons under the rank of knighthood, or of less property than the last mentioned, were confined to the use of cloth not exceeding four marks the whole piece, and were prohibited wearing silks and embroidered garments of any sort, or embellishing their apparel with any kind of ornaments of gold, silver, or jewellery. Rings, buckles, ouches, girdles, and ribands were all forbidden decorations to them; and the penalty annexed to the infringement of this statute was the forfeiture of the dress or ornament so made or worn.

In the next following reign, that of Richard II., a few sumptuary laws were enacted; but they were little attended to, as the nation generally, from the monarch downwards, seem to have had at that time an inordinate love of gay attire. Harding, who wrote his 'Chronicle' not long after this period, thus speaks of the apparel of the royal servants:—

> "There was a great pride among the officers
> And of all men surpassing their compeers
> Of rich array, and more courteous
> Than was before or sith and more precious.
> * * * * * *
> Yemen and gromes in cloth of silk arrayed,
> Satin and damask in doublettes and in gounes,
> In cloth of greene and scarlet, for unpayed (unpaid for)
> Cut worke was great both in court and tounes
> Bothe in men's hoodes and also in their gounes,
> Broudur (embroidery) and furre and goldsmith's worke
> all newe,
> In many a wyse each day they did renewe."

About the year 1400 Henry IV. revived the sumptuary laws of his predecessors, and tried to make them more stringent; but very little heed seems to have been taken of the enactment. No man, not being a banneret or person of high estate, was permitted to wear cloth of gold, of crimson, or cloth of velvet, or motley velvet, or large hanging sleeves open or closed, or gowns so long as to touch the ground, or to use the furs of ermine, lettice, or marten, except only armed chevaliers. Ornaments of gold and silver were forbidden to all who possessed less than two hundred pounds in goods and chattels, or twenty pounds per annum, unless they were heirs to estates of fifty marks per annum, or to five hundred pounds' worth of goods and chattels. It was also ordered that no man, let his condition be what it might, should be permitted to wear a gown or garment cut or slashed into pieces in the form of letters, rose-leaves, and posies of various kinds, or any such-like devices, under the penalty of forfeiting the garments, and the imprisonment of the tailor who made them.

Edward IV., about the year 1460, tried to effect what so many of the preceding monarchs had failed in. All knights below the rank of lords were prohibited from wearing cloth of gold, purple silk, or sable fur; simple esquires or gentlemen were prohibited from indulging in the use of velvet, damask, or figured satin, unless their yearly income reached the value of one hundred pounds; persons whose incomes amounted only to forty pounds a-year were forbidden the use of the better kind of furs, and also of ornamented girdles. No one under the title of a lord was to wear short jackets, or peaks to his shoes more than two inches in length. No yeoman was allowed to stuff his doublet with wool or cotton. The tailor who stuffed the doublet, or the shoemaker who made peaks to the shoes beyond the prescribed length, was to be anathematised by the clergy, and to pay a fine. It is difficult at the present day to appreciate all the reasons which led to such a curious minute enactment; but a glance at Figs. 358, 360, will give some idea of the absurdly peaked shoes and boots, against which one of the items of royal indignation was directed. Female dress, too, did not escape the attention of the law-makers. The wives of esquires and gentlemen were forbidden to wear cloth of gold, velvet, sable, fur, or figured satins. The wives, widows, and daughters of persons having less than forty pounds a-year were prohibited from wearing ornamented girdles, or kerchiefs exceeding a certain price, or any of the finer kinds of fur.

Henry VIII., though sufficiently inclined to all kinds of luxuries for his own person, did not fail to

legislate for his people in the matter. Black furs of a particular kind were to be restricted to the use of the royal family; while sable-furs were for the nobility above the rank of viscount. Blue or crimson velvet, or embroidered work, was prohibited to all below a certain rank. Velvet gowns, jackets, and coats, furs, of martens, and embroided cloths, were forbidden to those having less than four hundred marks per annum, except the sons and heirs of privileged parties, who might wear black velvet doublets and coats of black damask, tawny-coloured russet, or armlet. Satin and damask gowns were confined to the use of persons possessing at least one hundred marks per annum; and the wearing of printed or plain shirts, garnished with gold, silver, or silk, was forbidden to all persons under the rank of knighthood. The commonalty and serving-men were confined to the use of cloth of a certain price, and lamb's fur only, and forbidden the wearing of any ornaments or even buttons of gold, silver, or gilt work.

In 1579 Queen Elizabeth made a most bold and comprehensive attempt to give efficacy to royal edicts as to dress. The proclamation begins:—"Whereas, the Queenes Maiestie hath by sundry former proclamations notified unto her loving subjictes of this realme the great inconvenience and mischief that hath growen to the same, by the great excess of apparell in all states and degrees, but specially in the inferior sort, contrarie to divers lawes and statutes of the realme, whereof notwithstanding there hath followed no redresse, or very litel at al." The proclamation then urges upon all who exercise any kind of control or authority over other men, to exert themselves to make the laws obeyed in these matters. The mode in which justices, mayors, and sheriffs are to enforce punishment against the offenders, is then laid down. Next follows the manner of determining the income of a person (as an index to the kind of dress he may indulge in) by referring to the subsidy, or "Queen's taxes," which he pays; provision is laid down to meet the case of those who, "for the maintenance of their fond vanitie in apparell, will seeke to make their livings to be knowen and prooved to be greater than they were before in sessementes of subsidies taken to be;" and also for obtaining a bond or guarantee from those who, although from any cause not assessed in the subsidy-book, may yet be "founde in outwarde appearance more sumptuous in their apparell than by common intendement the values of their possessions or goodes may warrant." Lastly comes an exact enumeration of the materials for dress prohibited or permitted to any particular grade in society: the earl, the baron, the knight, the esquire; the countess, the baroness, the wife of knight or esquire—all are laid under orders as to the kind of silk, velvet, taffety, fur, or embroidery which he or she may wear.

This long proclamation relates more to the *materials* than to the *form* of dress. But there was also an order that "no person shall use or weare such excessive long cloaks, being in common sight monstrous, as nowe of late are become to be used, and before two yeeres past hath not bene used in this realme. Neither also should any person use or weare such great and excessive ruffes in or about the uppermost part of their neckes, as had not been used before two yeeres past; but that all persons shoulde in modest and comely sort leave off such fonde, disguised, and monstrous manner of attyring themselves, as both was unsupportable for charges, and undecent to be worne." Queen Elizabeth was not exactly the most proper person to inveigh against "excessive ruffs in or about the uppermost part of their neckes," if we may judge from the pictures of her own dress.

Other Laws affecting Woven Materials for Dress.

The laws to which the above details relate seem to have had their origin in a notion that the sovereign or the legislature knew better what a man could afford for dress than he did himself, coupled with the wish to keep up distinctions of rank by distinctions of dress. There were other laws, however, relating rather to the manufacture, and the revenue to be derived from it, than such considerations as the above; these we may shortly glance at.

Woollens were for many centuries the staple of English manufactures. After the reception by William the Conqueror of the Flemish clothiers (alluded to in a former page), we find frequent mention of wool and woollens in the statutes. Henry II. granted a fair for the clothiers and dressers to be held in the church-yard of Bartholomew Priory, near Smithfield, for three days, which spot still retains the name of Cloth-fair. The Flemish weavers established themselves in Wales, while there were guilds or companies of clothiers in London, Oxford, York, Nottingham, Huntingdon, Lincoln, and Winchester; all of whom paid a sum of money to the king for the privilege of carrying on the manufacture to the exclusion of other towns. There were, however, at several other towns, dealers who paid the king for licences to buy and sell dyed cloth; in some cases the width of the cloth being restricted, but in others not so. In the patent granted to the London clothiers, it was enacted that if any weaver mixed Spanish wool with English in making cloth, the chief magistrate of London should burn it. During the next three or four reigns the woollen manufacture greatly declined, owing to internal discord; and it required all the energy of Edward III. to restore it. Fuller, in his 'Church History,' thus relates the manner in which it was accomplished:—"The king and state began now to grow sensible of the great gain the Netherlands got by our English wooll. In memory thereof the Duke of Burgundy not long after instituted the order of the Golden Fleece, wherein, indeed, the fleece was ours, the golden theirs, so vast their emolument from their trade in clothing. Our Edward III. therefore resolved, if possible, to revive the trade of his own country, who, as yet, were ignorant of that art, as knowing no more what to do with their wooll than the sheep that weare it, as to any artifice and curious drapery, such their coarseness from want of skill in the making. But soon after followed a great alteration, and we shall enlarge ourselves in the manner thereof. The intercourse being large betwixt the English and the Netherlands (increased of late since King Edward married the daughter of the Earl of Hainault) unsuspected emissaries were employed by our king with those countries, who brought them into familiarity with such Dutchmen as were absolute masters of their trade, but not masters themselves, such as either journeymen or apprentices." These clothiers, having heard that they would be treated better in England than in their own country, came over, and were placed by Edward in various parts of the kingdom, where they established themselves. "And now," continues Fuller, "was English wooll improved to the highest profit, passing through so many hands, every one having a fleece of the fleece, sorters, kempers, carders, spinsters, weavers, fullers, diers, pressers, packers; and those manufactures have been heightened to a higher perfection since the cruelty of the Duke of Alva drove over more Dutch to England."

The wool, as distinct from the manufacture, was subject to numerous enactments at different times. The merchants at first paid a fine to the crown for leave to export wool, which could not be exported without this permission. Edward I. made this quite a source of revenue, raising the fine as often as he could. The wool-growers, however, did not tamely submit to this; and there was constant strife on the subject between the monarchs and the people for several reigns. Edward III., as a further means of improving the woollen manufacture in England, prohibited the exportation of wool altogether. A constant scene of fluctuation took place in the enactments of the next few reigns, concerning the export of English wool, and the import and export of manufactured woollens, as also the mode of making and selling cloth generally. At one time a tax was laid on all cloth exported; at another on all cloths sold at home; at another a law was passed that cloth inspectors should be employed in the principal clothing towns; at another that woollen cloths and caps should not be imported; at another that the length, breadth, and weight of woollen cloths should not be below a certain minimum. Sometimes the wearing of particular kinds of garments was ordered, as a means of giving a stimulus to the manufacture; and, in short, for many centuries the legislative interferences with the natural progress of the woollen manufacture were frequent and changeable, according as the importers or the exporters, the growers or the manufacturers, the monarch or the people, happened to be the most powerful. In 1571, for example, there was an act of parliament passed providing that all persons above the age of six years, except the nobility and other persons of degree, should, on Sabbath days and holidays, wear caps of wool manufactured in England. The law principally affected citizens, artificers, and labourers. These woollen "statute caps" are sketched in Fig. 370, and were alluded to by Shakspere in 'Love's Labour's Lost." The law in question did not remain in force many years; and it was nearly a "dead letter" while yet on the statute-book.

The reason why these details have been confined to woollens is that they formed far the larger part of the textile goods made in England. It is believed that *cotton* was not manufactured in England until about two centuries ago; while *silk*, though so largely spun and woven in France and Italy, was very little manufactured in England until the expulsion of the silk-weavers from Brabant to England in the time of Elizabeth. *Linen* has been the subject of many enactments, but its importance has been materially less than that of woollen.

Without attempting to follow the course of legislation in respect to dress and the materials of clothing (glanced at here only as a means of showing the kind of agency which has occasionally had influence in the matter), we may present a few more examples of the change of costume in different centuries.

English Dress from the Sixteenth Century.

At the close of the fifteenth and the beginning of the sixteenth centuries the English dress was, according to Strutt, "exceedingly fantastical and absurd, insomuch that it was even difficult to distinguish one sex from the other." Many of the garments such as "petticoats" and "stomacher," were worn by both sexes; of which examples are found in the instructions given to a chamberlain or valet of the royal household, wherein he is advised, by the time his master rises, to provide "a clene sherte and breche, a pettycotte, a doublette, a long coate, a stomacher, hys hozen, hys socks, and hys schoen." And again:—"Warme your soverayne his pettycotte, his doublette, and his stomacher, and then put on his hozen, and then his schone or slippers, then stryten up hys hozen mannerly, and tye them up, then lace his doublette hole by hole," &c.

Soon after the accession of Henry VIII. the men's "pettycottes" were superseded by "trauses," or close hose, fitted exactly to the figure. After this came in a fashion about as monstrous as any that had preceded it. This was the use of "trunk-hose," so stuffed out with rags, wool, tow, or hair, as to give to the leg a shape anything but consistent with that naturally belonging to it. The ladies then imitated the men in giving a fullness to their dresses, at first in a moderate degree, but the "fardingale" at length set all the preceding forms of dress into the shade; although, in its turn, it was surpassed by the hoops of the last century. Some examples of this protuberant dress, in moderate form, are observable in Figs. 376, 378. A story is told by a writer of a somewhat later period, that when Sir Peter Wych went as ambassador from Turkey to England, his lady accompanied him to Constantinople; and the Sultaness, having heard much of her, desired to see her. Whereupon Lady Wych, accompanied with her waiting-women, all of them wearing their great fardingales, went to the seraglio. The Sultaness received her with great respect, but wondering at the strange appearance she presented, inquired whether that shape was peculiar to the women of England; to which Lady Wych felt it necessary to reply by explaining the nature of the ample but disguising form of dress.

There was a writer, Philip Stubs, who, in the sixteenth century, wrote a work called the 'Anatomy of Abuses.' It is rather a snappish and scolding complaint against the dress and customs of the people at that time, but it is valuable as giving some curious details concerning the materials of which the dresses were often made. He says there was a great desire for fine quality in the cambric, holland, or lawn, of which the shirts were made, insomuch that he had "heard of shirts that have cost, some ten shillings, some twenty, some forty, some five pounds, some twenty nobles, and, which is horrible to hear, some ten pounds, a-piece; yea, the meanest shirt, that commonly is worn of any, doth cost a crown or a noble at the least." They must, indeed, have been extraordinary shirts to have cost ten pounds each, especially at the value which money then possessed. He next proceeds to say:—"I have heard my father and other wise sages affirm, that in his time, within the compass of four or five score years, they went clothed in black or white frize coats, in hozen of housewife's garzie of the same colour that the sheep bare them; the want of making and wearing of which cloth, together with the excessive use of silks, velvets, satins, damasks, taffetaes, and such like, hath and doth make many thousands in England to beg their bread. Of these hozen some were strait to the thigh, and others some a little bigger, and when they wore shirts of hemp and flax, but now these are too gross, our tender stomaches cannot easily digest such rough and hard meat, men were stronger, more healthfull, faire rcomplexioned, longer lived, and, finally, ten times hardier than we be now."

After venting his wrath against the ruffs worn round the neck, the censor proceeds to notice the silk, velvet, taffeta, and fine scarlet "of ten, twenty, or forty shillings the yard," thereby implying that the materials, whether woven in England or on the Continent, were of a rich and costly character. This tendency of satirical writers to comment on the prevailing taste of the day was exemplified in many quarters. For instance, at a somewhat later date than that to which Stubs refers, a scene in a play gives the following list of trappings belonging to a lady's wardrobe:—"Five hours ago," one of the characters says, "I set a dozen maids to attire a boy like a nice gentlewoman; but there is such doings with their looking-glasses, pinning, unpinning, setting, unsetting, formings, and unformings, painting of the veins and cheeks: such a stir with sticks, combs, cascanets, dressings, purls, fall squares, busks, bodices, scarfs, necklaces, rabatoes, borders, tires, fans, palisadoes, puffs, ruffs, cuffs, muffs, pusles, fusles, partlets, friglets, bandlets, fillets, corslets, pendulets, amulets, armulets, bracelets, and so many *lets* that she is scarce dressed to the girdle; and now there is such calling for fardingales, kirtles, busk-points, shoe-ties, and the like, that seven pedlers' shops, nay, all Stourbridge-fair, will scarcely furnish her. A ship is sooner rigged by far than a gentlewoman be ready."

After the complex and expensive dress during the Tudor dynasty, Charles I. brought a more simple and becoming style of costume. Indeed, Mr. Planché thinks it the most elegant and picturesque attire ever worn in England. But the next reign, that of Charles II., undid all this improvement, and introduced wigs, feathers, frills, and coats of a most extraordinary shape.

It was about this reign that the manufacture of silk

384.—Reign of Queen Anne.

386.—Early part of Eighteenth Century.

385.—Reign of George I.

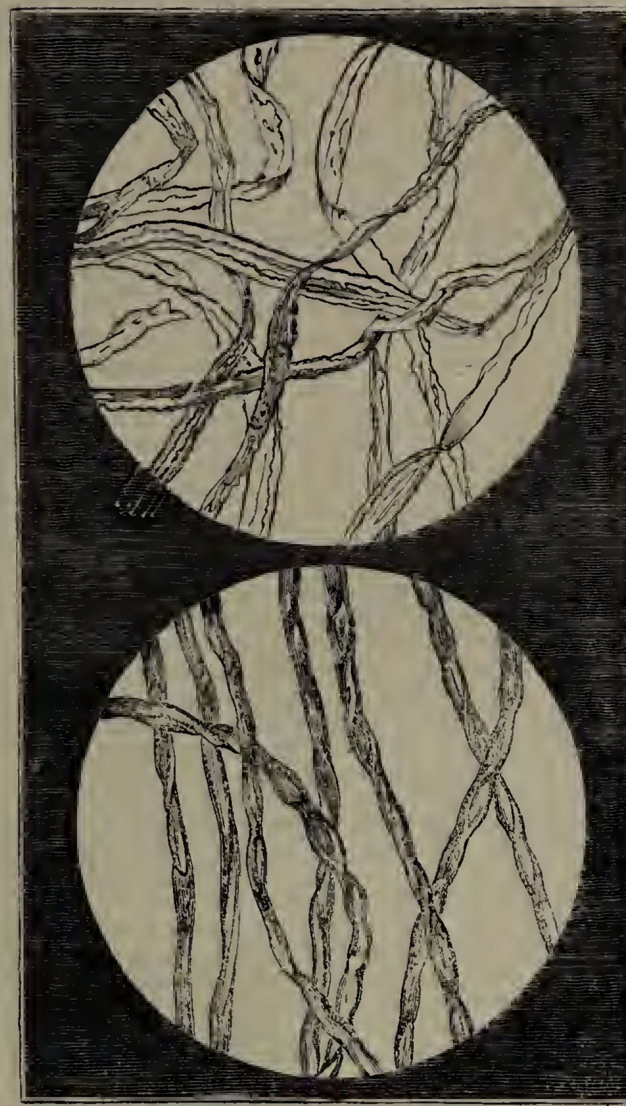
387.—Early part of Eighteenth Century.

389.—Latter part of Eighteenth Century.

388.—Reign of George II. (From Hogarth.)

390.—Latter part of Eighteenth Century.


391.—Sea Island or Long-Staple Black-seeded Cotton of Georgia.


397.—Cotton fibres, greatly magnified.


392.—Short-Staple or Green-seed Cotton.


393.—Gossypium herbaceum—Cotton Plant.


394.—Gossypium religiosum—Cotton Plant.


398.—Cotton fibres, greatly magnified.


395.—Gossypium Barbadense—Cotton Plant.


396.—Cotton: showing a pod bursting.

became somewhat important in England. This favourite material for clothing is noticed occasionally in earlier legislative proceedings in England. For instance, "women employed upon works in silk" are mentioned in an act of Edward III.'s reign. A century afterwards a law was passed for the protection of the silk-women of London, against the importation, for five years, of foreign articles which were enumerated and described as similar to those manufactured by them; such articles comprising only "twined ribbands, chains, and girdles," and similar small wares; and a few years afterwards, another protective enactment mentioned "laces, ribands, and friezes of silk, silk twined, silk embroidered, tires of silk, purses, and girdles," as among the English manufactures requiring protection. These English goods appear to have been either higher in price or worse in quality (or both); for as soon as these protecting or prohibitory laws were at any time removed, the "silk women" complained immediately that the foreigners beat them out of the market. It is believed that no manufacture of "broad silks" or woven goods for making up into garments was carried on in England to any extent worth mentioning, till towards the beginning of the seventeenth century. "It was only near the close of the reign of James I.," says Mr. Porter, "that, upon some encouragement afforded by that monarch to Mr. Burlamach, a merchant of London, some silk-throwsters, with silk-dyers and broad-weavers, were brought from the continent of Europe, and a beginning was made in the manufacture of raw silk into broad silk fabrics, which has since become of so much profit and importance to the country, and which then increased so rapidly, that in the year 1629 the silk-throwsters of London formed a body of sufficient importance to be incorporated, under the style of "the Master, Wardens, Assistants, and Commonalty of Silk Throwsters." By the year 1630 the manufacture had so far advanced as to lead to the following precautionary proclamation:—"Whereas the trade in raw silk within this realm, by the importation thereof raw from foreign parts, and throwing, dyeing, and working the same into manufactures here at home, is much increased within a few years past. But a fraud in the dyeing thereof being lately discovered, by adding to the weight of silk in the dye beyond a just proportion, by a false and deceitful mixture of ingredients used in dyeing, whereby also the silk is weakened and corrupted, and the colour made worse; wherefore we strictly command, that no silk-dyer do hereafter use any slip, alder-bark, filings of iron, or other deceitful matter, in dyeing silk, either black or coloured; that no silk shall be dyed of any other black but Spanish black, and not of the dye called London black, or light weight; neither shall they dye any silk before the gum be fair boiled off from the silk, being raw."

As we have just seen that it was not till comparatively a late period that it was possible to make dresses of silk spun and woven in England; so there is also proof that the general introduction of cotton did not take place earlier, nor even so early. Two centuries ago the town of Manchester, now the centre of the most gigantic manufacturing system that the world has ever seen, had only just begun to assume a respectable position in this department: and no other town was of higher import in the matter. The Manchester men at that time supplied the home trade with several kinds of cotton goods, and also furnished some as an article for export to the Levant. The linen manufacture was also at that time carried on there, and indeed linen-yarn was used for the warps or "long threads" of cotton goods generally; so that linen, in point of fact, paved the way for the introduction of cotton. Yet the commercial arrangements of the town were of a very humble description. The capital of the merchants was very small, and all their concerns were managed with great frugality. Owing to the bad state of the roads, and the entire absence of inland navigation, goods could only be conveyed on pack-horses, with a gang of which the Manchester chapmen used occasionally to make circuits to the principal towns, and sell their goods to the shopkeepers.

We shall find, then, that in all the matters relating to costume at or about the period of which we are speaking, woollens and linens were still the standards of home manufacture; silks were either imported from abroad, or were looked upon as rather a new article of manufacture in this country; while cottons were a coarser and altogether less important material than any of the other three. The presents made to Queens Mary and Elizabeth by their more wealthy subjects, and the "Maundy" gifts of these times, have often been alluded to as illustrating the manners and customs of the period; but we may here say a few words respecting them, as showing the kind of materials used. Among the "Newe Yere's Guiftes" presented to Queen Mary in 1556, was an immense variety of sumptuous apparel, a great part of which must evidently have been made from foreign materials. Her royal sister presented "the fore-part of a kyrtell, and a peire of sleves of cloth of silv', richly embroudered all ou'r with Venice silver, frayzed with silv' and blake silk." The Duchess of Somerset gave "a smoke, wrought all ov' with silke, and collor and ruffes of damaske gold, purle and silver." Others among the ladies of title presented "a faire smoke, wrought with golde and blacke silke,"—"two smockes, wrought with blake worke,"—"a wastecote of white satten, embraudered with silver,"—"a faire smoke of white worke, Flaunders making,"—"foure wastcotes, foure peire of slevys, and foure peire of hoosen of Garnesey making,—"Foure 'handkercheues edged with silke and golde,"—"sixe handkercheues of white worke." Without commenting on such gifts as "eight turqueyhennes, delyuered into the kytchen," or "two Gynny-cokks scalded," or "sixe boxes of marmalade and cordyall,"—it will be sufficient to remark, in relation to the articles of dress, that silk seems to be mentioned more as a trimming or garniture than as the substantial material; and this accords with what is known of the silk manufacture in England at that time, which consisted rather in "small wares," such as laces, braids, and fringes, than in "broad silks."

The *Maundy*, or presentation of gifts to the poor by the sovereign, on the Thursday before Easter (formerly accompanied by the washing of their feet, as a token of humility) gives us intimation of the kind of materials used for garments for the poorer classes at different times; from which we find that in Elizabeth's time there was no mention of *cotton*, which there would certainly have been had it been at that time a cheap and well-known material. In the Maundy for 1579, the master of the wardrobe is ordered to deliver the following goods for use on the occasion:—"One hundredth thyrtie and fyve yerdes of russet cloth, to make fourety and three gounes for fourtye and fyve poore women; and fourety and fyve peire of single soled shoowes for them. Item, two hundredthe fyvetye and eight elles of lynen cloth, as well to make smockes for the said poore women, as also to be employed in the service of our said Maundye. Item, twentye and sixe peire of bearinge and trussinge sheetes of two bredthes and a half of Hollande cloth, and two elles thre quarters longe the pece. Item, thyrtie elles of diaper of elle quarter brode; and eighteene napkyns, cont' one elle longe the pece." Linen, diaper, and russet, made from the two staple materials, flax and wool, are here the materials alluded to; and it was not till many generations afterwards that cottons came to form a notable part of English attire.

The general appearance of the costume in England, both of the more wealthy and the more humble classes, from the time of the Tudors to the latter part of the last century, may be gathered from the several woodcuts given in the preceding pages.

Mr. Planché characterises the general English dress in the time of Charles I., as "the most elegant and picturesque costume ever worn in England, and from the circumstance of its being the habit of the time in which Vandyke painted, it has acquired the appellation of the Vandyke dress. It has been familiarised to us not only by the numberless prints from the works by that great master, but through the medium of theatrical representations, being, of all costumes, perhaps the best adapted for the stage, and therefore generally selected for such plays as are not fixed by their subject to some other particular era." Just before the "Vandyke dress" was introduced, the beaux of the day were wont to search Europe over for fashions, and to form a composite dress made up from scattered fragments. There is a passage in one of Ben Jonson's comedies in which no less than eight countries contribute to the mode or the material of a fine gentleman's dress:—

> "I would put on
> The Savoy chain about my neck, the ruff,
> The cuffs of Flanders, then the Naples hat,
> With the Rome hatband, and the Florentine agate,
> The Milan sword, the cloak of Geneva set
> With Brabant buttons."

During the civil wars the dress of the cavaliers was picturesque, consisting of a silk or velvet doublet, with large loose sleeves slashed up the front; the collar covered by a falling band of the richest point-lace; a short cloak worn carelessly over one shoulder; fringed breeches, meeting the tops of the wide-spreading boots, also fringed; and a broad Flemish beaver hat with a feather. Sometimes the doublet was exchanged for a buff coat or jerkin.

With Charles II. came in the flowing but unsightly wig, which lasted through three or four reigns. The petticoat-looking doublet—the frills, and laces, and fringes hanging from the knee; the oddly-shaped shoes, and the ugly walking-coat, were a departure in the wrong direction from the dress of the preceding reign. The hat and feather by degrees gave way to the cocked hat, the frills disappeared from the knees, and the general dress assumed the somewhat stiff and starched character of William III.'s reign.

With the eighteenth century came in those formal and inelegant kinds of costume which Addison, Hogarth, and Reynolds successively placed before us. If we compare the four figures in Fig. 386, we shall find that *a* may represent the general dress of the better classes during the reign of Queen Anne; *b*, about the year 1735; *c*, 1745; and *d*, 1755. "Square-cut coats and long-flapped waistcoats with pockets in them," says Mr. Planché, "the latter meeting the stockings, still drawn up over the knee so high as to entirely conceal the breeches, but gartered below it; large hanging cuffs and lace ruffles; the skirt of the coat stiffened out with wire or buckram, from between which peeped the hilt of the sword, deprived of the broad and splendid belt in which it swung in the preceding reigns; blue or scarlet silk stockings with gold or silver clocks; lace neckcloths; square-toed, short-quartered shoes, with high red heels and small buckles; very long and formally curled perukes, black riding wigs, bag-wigs, and night-cap wigs; small three-cornered hats laced with gold or silver galloon, and sometimes trimmed with feathers, composed the habit of the noblemen and gentlemen during the reigns of Queen Anne and George I." After the battle of Ramilies came in the "Ramilies cock" of the hat, and a plaited tail with a riband bow to the wig. In the next reign the "tie-wig," the "bob-wig," and the "pig-tail," were introduced; as also that most dirty and incomprehensible fashion of powdering the hair. The brims of the cocked hat are sometimes likened to "a spout:" and at other times to "a minced pie."

The ladies' costume, in the earlier half of the last century, was even less elegant than those of the men. The three representations in Fig. 387 give the prevalent form: *a*, in 1735; *b*, in 1745; and *c*, in 1755; and there would be but very few persons in the present day who would venture to speak favourably of such attire. To these succeeded head-dresses of most extravagant form, hoops of enormously wide dimensions, and trains dragging on the ground. But to follow the vagaries of fashion during the last hundred years is no part of our object; suffice it to say, that about (or soon after) the time when George III. ascended the throne, the manufacture of cotton assumed such an important position in England as to render that material more and more fitted for articles of dress; while the other three—woollen, silk, and linen—also became developed in various ways. When calico-printing became successfully practised, it naturally exerted some influence on the patterns, colours and appearance of many of the materials for clothing, since it produced in an easier way many of the devices which had before been only produced by elaborate arrangement of the loom.

We shall now be prepared to consider, in regular order, the principal modes in which art has been applied to this all-engrossing subject; taking each one of the chief materials in succession.

COTTON: ITS CULTIVATION AND MANUFACTURE.

THE cotton which forms the object of such a gigantic manufacture is a delicate fibrous substance found within the seed-pod of a tropical plant, of which the varieties are very numerous. It is in fact a series of vegetable hairs springing from the surface of the seed-coat, and filling up the cavity of the vessel in which the seeds are contained.

Varieties of the Cotton-Plant.

The number of different kinds of cotton is very considerable, although, as in most similar cases, they are by no means equal one to another in respect to the quality of the cotton produced. Figs. 391 to 396, together with Figs. 399, 400, will give an idea of the appearance of many of these kinds in different stages of growth. They belong to the botanical genus *Gossypium*, of which the following are the chief characteristics:—They vary in height from three or four to fifteen or twenty feet, according to the species. Sometimes the branches become woody, but they always partake very much of an herbaceous character. The leaves are downy, and more or less lobed, being sometimes however, near the top of the stem, undivided. The flowers are either yellow or dull purple. The seed-vessel is a capsule opening into three, four, or five lobes, and then exposing many seeds enveloped in cotton, which sometimes adheres to them so firmly that it is separated with difficulty, but in other cases parts from them freely. The fibre is in some species much longer than in others, thereby giving rise to the commercial names of "long-staple" and "short-staple" cotton.

A few of the principal varieties will suffice here to exemplify the plant generally. The *Gossypium herbaceum*, or common herbaceous cotton-plant, is the species most generally cultivated. It is an annual, and rises only to the height of about eighteen inches. It bears a large yellow flower with a purple centre, which produces a pod about the size of a walnut; and this pod bursts when ripe, exhibiting to view the fleecy cotton, with the seeds securely imbedded in it. This variety is sown and reaped like corn. It grows in many parts of Southern Europe, Western Asia, and North America. The *Gossypium arboreum*, or tree-cotton, grows to a much greater height. If left to grow as it will, without being pruned, it sometimes attains a height of twenty feet. Marco Polo, the Venetian, who travelled in Asia four or five centuries ago, spoke of this tree thus:—"Cotton is produced here (Guzerat) in large quantities, from a tree that is about six yards in height,

and bears during twenty years; but the cotton taken from trees of that age is not adapted for spinning, but only for quilting." The *Gossypium Indicum*, or Indian cotton, is also a tree-like variety, having a woody stem rising to the height of ten or twelve feet. It continues in full bearing during several years. The *Gossypium hirsutum, vitifolium, religiosum, tricuspidatum*, &c., are other varieties, differing in various points from those above named.

The colour of the seed seems to be connected in some way with the quality of the cotton fibre. The number of seeds in one pod varies greatly, the range being from ten to thirty. There is a West Indian wild cotton-plant, of which the seeds are rough and black, and the cotton pale red, with so short a fibre that it cannot be spun. The Indian cotton has a dark-brown seed streaked with black, and fibres very white and fine. There is a kind which produces fibres almost equal to silk in beauty and fineness, and at the same time very elastic and very white; but it is not much cultivated on account of a difficulty in cleaning it, arising from the close adhesion of a kind of green moss to the mass of fibres. The seeds of the Jamaica cotton are smooth, but so brittle as to break in clearing the fibres from them, so that the species is much less valuable than it would otherwise be. The "sea-island cotton," derived from the "*herbaceum*," and brought from Georgia in the United States, is commercially the most valuable of all, and that to which the Liverpool merchants direct more of their attention than to any other.

Cultivation of the Cotton-Plant.

The quantity of cotton wool sent from America to England is so immense that the cultivation is regarded as one of great consequence, and involving attention to a number of minute details. Dr. Ure, in his valuable work on the 'Cotton Manufacture,' has given accounts of the mode of proceeding in Georgia, furnished to him by two experienced planters there; and we cannot do better than avail ourselves of a few details from such a source.

The prevailing process in Georgia is to form the ground into ridges five feet in breadth, extending in straight lines over the whole field. If the land be at all low, and subject to be overflowed, these ridges are intersected by ditches, at intervals of about a hundred feet from each other, for receiving the water that may collect in the hollow spaces between the ridges on which the cotton-plants are reared. These hollows correspond to the water-furrows in wheat husbandry, and serve the same purpose of drainage. The ridges rise about ten inches above the level of the hollows, the crown being flat and regular; and a trench is made along the middle of the ridge, from two to four inches deep, according to the time of planting, which extends from the 1st of March to the 1st of May, the first half of April being deemed the best period. It is found that when the cotton is planted early in March, before the sun has warmed the soil to any great depth, it is necessary to deposit the seed in drills not more than two inches deep, in order to ensure germination; whereas later in the season, when the heat is greater, the drills are made four inches deep, to keep the seed moister and cooler.

The seed is sown in the ground in the proportion of about a bushel to an English acre. The persons employed in sowing are generally divided into parties of three each. One person opens the drill along the top of the ridge; the second (who is the most skilful of the three) drops the seed into the trench; and the third follows with a hand-hoe to turn back the soil, while still moist, over the seed in the trench. These persons are principally women.

The crop is subject to many sources of injury, some of which are within the power of the planter to contend against, while others baffle all his care. A single night's frost, which sometimes occurs so late as the month of April, will ruin his whole prospect, and require a renewal of the labour; nay, one day of a strong north-east wind will blight a field of growing plants. If these sources of trouble are escaped, there is another often looked forward to with dread. This is a species of cockchafer or cutworm, which cuts the young and tender plants close to the ground, sometimes ruining a whole field at once. When apprehension from these dangers is over, then comes on the labour of thinning the plants, which would injure each other if left as close as they were sown. The prosecution of this labour is divided into three periods, the planter at each period or stage weeding out the weakly plants as the vigorous ones increase in size, to be left to grow from six to twenty-four inches apart, according to the fertility of the soil and the expected size of the shrub. The cotton-plant is of the tap kind, which sends its root straight down into the ground, and draws much of its nourishment from the atmosphere by means of its broad leaves; and the distance between the plants in the ground is regulated according to this circumstance.

Whenever the periodical thinnings take place, the field is carefully cleared with the hand-hoe from weeds, and fresh soil is gathered round the remaining plants to support them against the wind, whereby they are easily bent over, on account of their small slender stem. These several operations continue till about the third week in July—the number of thinnings, hoeings, and weedings depending on various circumstances. About this time the summer rains usually set in: they are not tropical in their violence, but are often pretty heavy. Up to that time the climate of the Georgian cotton districts is temperate, and the atmosphere is fresh and enlivening; but dark and dense clouds gather about the rainy seasons accompanied by lightning, and other indications of stormy weather. At this season all labour in the field ceases, for any attempt to stir the ground would be apt to loosen the roots; indeed the large leaves are so weighty with the moisture resting on them, that the plants are only held up by being well bedded at the roots. As the spring had its sources of mischief to the cotton-grower, so has the autumn. The rains frequently beat off the fruits and leaves; and there also appears about this time a caterpillar which commits great ravages. This insect deposits its eggs upon the leaves of the cotton-plant during August: they hatch a few hours after they are deposited, and are so small at first as to be hardly discernible to the naked eye. They do little or no damage during the first nine or ten days of their life, but a few days before completing their growth, they become so excessively voracious as to destroy an entire plantation in a few hours. Instances have been known of four hundred acres of cotton plantation being ruined in four days by them.

Supposing the planter to have escaped all these multifarious evils of winds, insects, and rains, the cotton-fields begin to display a very beautiful appearance. "Wide-waving groups of viny foliage blended with three-coloured blossoms of brilliant hues, and pods of darker shades in various states of ripeness. When the flower comes forth, it has a fine yellow colour, which it retains during the first day; under the influence of the night it changes to a red or crimson hue; in the third day it darkens into a chocolate-brown, and then falls to the ground, leaving a pod already half an inch in diameter." The interval between the appearance of the blossom and the maturation of the fruit is very variable, being altogether dependent on the season.

The cotton pods begin to open about the 1st of August; from which time to the 1st of December the whole attention of the cultivator is directed to the "picking" of the cotton, as the pods daily open. During the autumnal season in Georgia and South Carolina, upon the sea-coast, the winds are violent and the rains heavy, so that the picking is a tedious though not a laborious operation; and the persons employed may be expected to gather from twenty-five to fifty pounds of cotton per day each.

The cotton which is thus gathered consists of the tufts or small soft balls contained in the seed-pods; and the preparation for the market begins as soon as the picking generally is ended. The tufts, as plucked from the cotton, are put into a bag to the amount of about half-a-bushel, the bag being suspended from the neck or waist of the gatherer. When full, this bag is emptied into a large basket, which contains the amount of each person's gathering in the course of a day. In the evening the crude cotton is brought home, weighed, and deposited in the storehouse; whence, next morning, if the weather be fine, it is taken and spread upon drying-floors, made of two-inch American pine-planks; from twenty to forty feet of flooring being required for every hundred acres of cotton under cultivation. If the cotton be plucked in dry weather, one day's exposure in this way is sufficient; but several days are required if the cotton had been pulled in rainy weather. The cotton is left on the drying-floor only so long as is absolutely necessary to prevent it from fermentation afterwards, since both sunshine and cold dry winds are injurious to the delicate fibres.

As a means of separating any sand, broken leaves, or other extraneous matters which may have become mixed up with the cotton, it is often passed through a machine called a *whipper*. This consists of a long cylindrical cage made of reeds, wooden bars, or wire, six or eight feet in length by two in diameter, closed at one end and opened at the other, and supported at the two ends by feet of different heights, so as to let the cylinder lie in a sloping position. At the higher end a hopper of about a bushel capacity admits the cotton, which is put through it into the cylinder. There is a shaft running down through the middle or axis of the cylinder, by which it is made to rotate, and which has also cross-bars attached to it. As the cotton descends through the cylinder, it is whisked and turned and tossed about, by which it becomes so far loosened as to allow the sand and dirt to separate from it, and to fall through the open wire-work of the cage or cylinder. This kind of action is something like that which we shall presently have to speak of, under the name of *willowing*; but here it has relation only to the separation of the coarser impurities.

Microscopic Appearance of the Cotton-Fibres.

It may be well here to speak of the remarkable structure of the fibre derived in this way from the cotton-plant; since the facilities for the subsequent manufacture depend mainly on this structure.

These fibres, which seem to bear nearly the same relation to vegetation that hair does to animals, partake of the character of cellular tissue, in being thin and transparent. They are long weak tubes which, when immersed in water and examined under the microscope by transmitted light, look like flat, narrow, transparent ribands, all entirely distinct from each other, and with an even surface and uniform breadth. It is only in some few cases that *joints* are observable in the fibre; and when this happens, the joint is marked by a line directly across the breadth. Sometimes there is an indication of fine grains in the interior of the tube; but in general the tube appears to be empty: if strained singly, they have little strength; so that it is only by combining many of them together that they acquire sufficient tenacity for textile purposes. Fibres of flax or linen present a very different appearance from these; for though they are tubular, yet these tubes are so grouped up into bundles that it is difficult to detect them singly even by the microscope. The tubes are thick-sided, and are formed of woody tissue, those of cotton being cellular tissue. The joints of the flax-fibre are oblique and overlapping; and throughout its whole structure there is greater strength in the individual fibres than in those of cotton; a circumstance which sufficiently explains the superior strength of linen over calico or any other kind of cotton.

Dr. Ure gives the result of an extensive series of examinations to which he subjected cotton-wool as well as other fibres employed in textile manufactures; and the result is well calculated to excite surprise on account of the extreme minuteness of the fibres so examined. For instance, Sea-island cotton has an average diameter of about $\frac{1}{2000}$ of an inch; upland cotton, $\frac{1}{6000}$; Surat, $\frac{1}{500}$ to $\frac{1}{2000}$; and various other kinds have a diameter varying from the one to the other of these two extremes. The fibres generally terminate in very fine points, and have also fine edges. The entanglement of the filaments, to which the superior spinning qualities of cotton are due, is ascribed chiefly to their spiral structure and their elasticity, inasmuch that when one is pulled out, it draws others along with it. "If, during this extrication of the filaments," says Dr. Ure, "a twisting motion be communicated to them, they will form a cohesive thread. The finer, the more uniform, the more cylindrico-spiral, the longer, and more elastic the filaments are, the more capable they will be of forming fine yarn. When they are short, and consist of rather broad and flimsy ribands, they will be ill adapted to machine-spinning, though still susceptible of being spun by the tact of delicate fingers. We can thus understand how the Hindoo women manage to spin fine yarn from the Dacca cotton, which is the growth of an unequable wool consisting of flimsy ribands, like most of the India cottons. . . . . There can be no doubt that the cotton filaments are hollow cylinders, prior to the state of maturation: they then become flattened and tortuous, in a greater or less degree. The more nearly cylindrical they remain, the stronger and more pliant to the spindle will they be found."

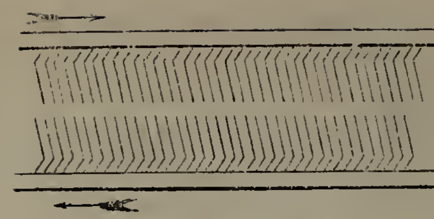
It is partly with a view of determining the relative flatness or cylindrical form of the fibres that the cotton brokers and dealers subject them to examination before purchase; as well as for the determination of the length of the fibre. The fineness, the length, the strength, the softness, the equality, the freedom from knots and impurities—all are taken into the account. A handful of the cotton is taken, and pressed and drawn out between the thumb and two forefingers, as a means of determining the length and fineness. Over and over again is this done, the fibres being brought pretty well parallel one with another, whereby the various qualities of the cotton are tested. An experienced cotton-broker acquires a remarkable facility in this examination; insomuch that, even in the dark, he could determine the country, quality, and value of the cotton under examination.

In Figs. 397, 398, 401, 402, may be seen six examples of the very curious appearance which the fibres of cotton present when viewed under a powerful microscope.

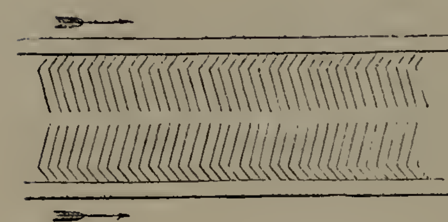
Cleaning and Packing for the Market.

As it is an important matter to send the cotton to market in as clean a state as possible, both for saving of freight and increase of price, many contrivances have been introduced for this purpose. In India, however, the greater part of the cotton is picked by hand. Abel describes a machine which he observed the Chinese to use for this purpose:—"It consisted of two wooden cylinders placed horizontally one above the other, on a stand a few feet from the ground. The cylinders, very nearly touching, were put in motion by a wheel acted upon by the foot. The cotton being brought to one side of the crevice intervening between them during their revolution, was turned over to the opposite; whilst the seeds, being too large to enter, fell at the feet of the workman." Thumberg, in Batavia, saw cotton cleansed from the seed by being laid out on extended cloths, and beaten with sticks till all the seed was perfectly separated from it.

399.—Gossypium tricuspidatum—Cotton Plant.



410.—Teeth for Carding Cotton.



409.—Teeth for Carding Cotton.

400.—Gossypium arboreum—Cotton Plant.

404.—Sir Richard Arkwright, Inventor of the Spinning-frame.

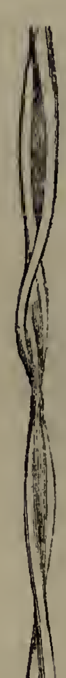
405.—Picking Cotton.

407.—Willowing-machine, for Cotton.

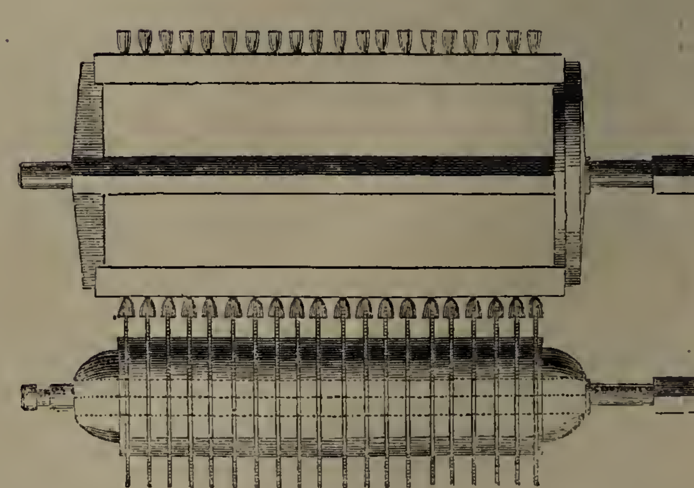
408.—Teeth for Carding Cotton.

401.—Cotton fibre, magnified.

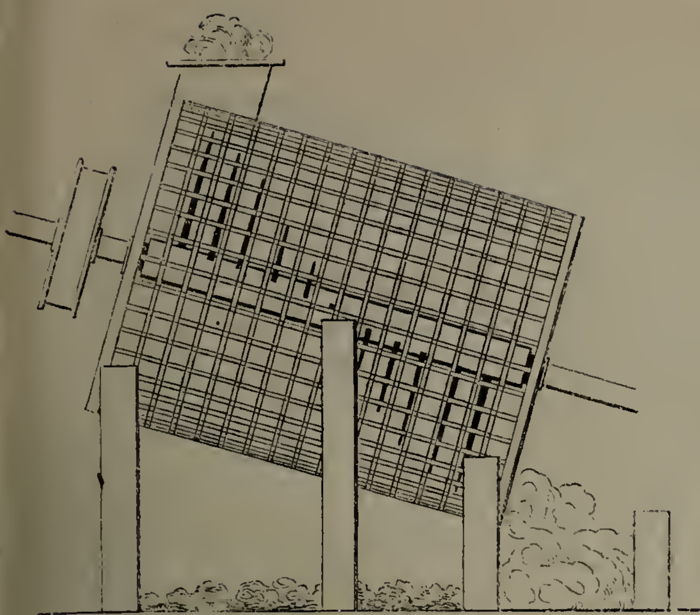
406.—Blowing of Cotton, as practised in India and China.



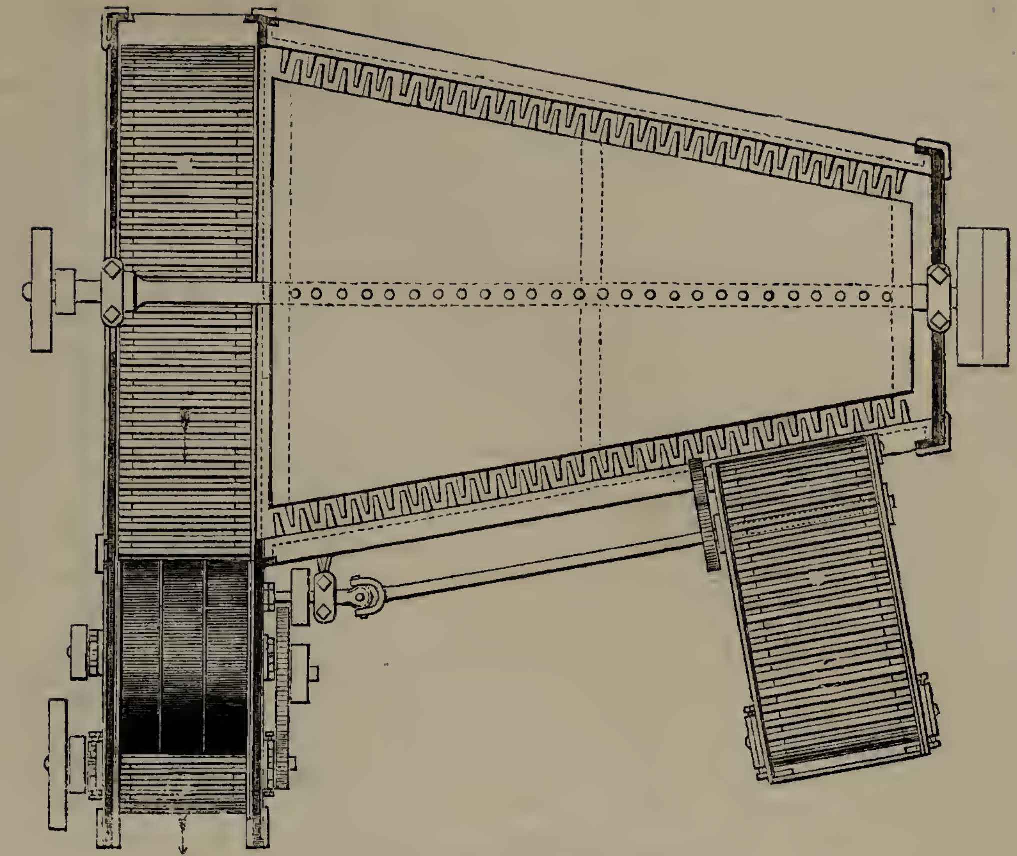
402.—Cotton fibre, magnified.



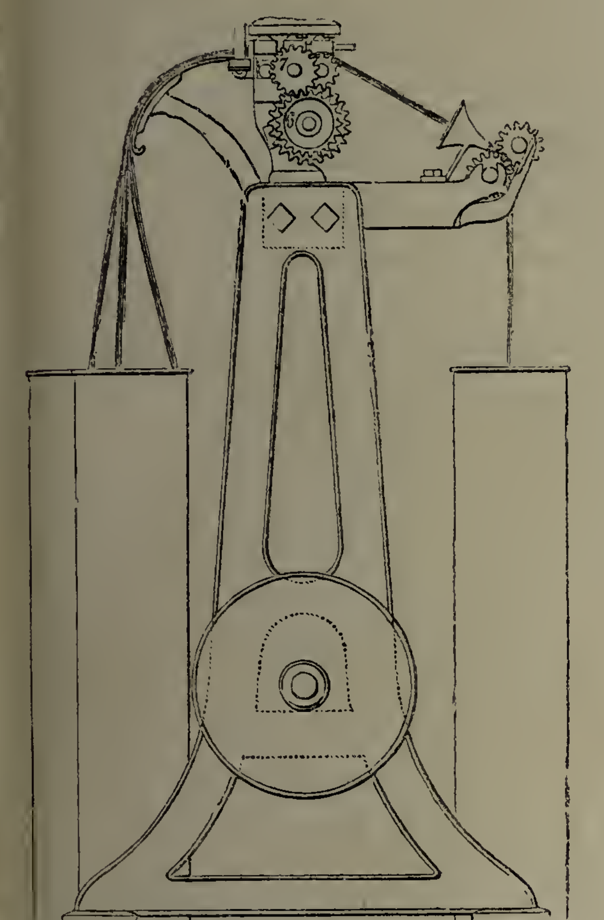
403.—Machine for cleaning.



411.—Normandy Willowing-machine.

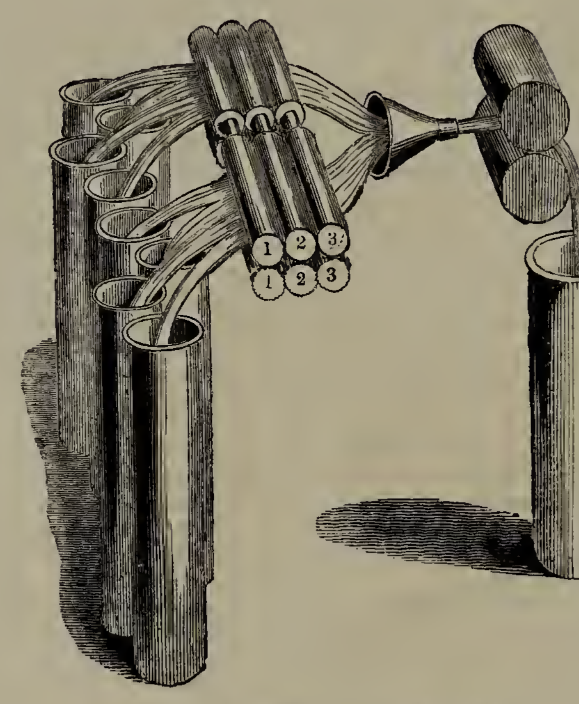


412.—Willowing-machine, for Cotton.

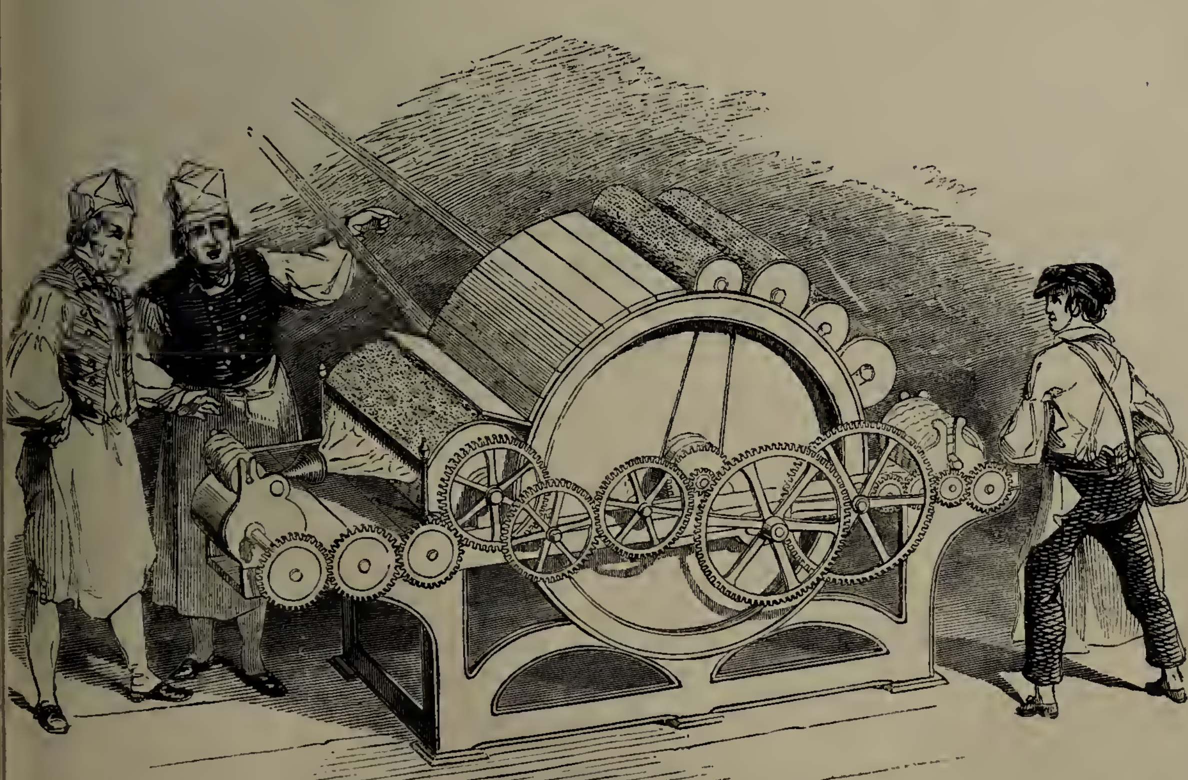


413.—Drawing-frame for Cotton.

417.—Mr. Strutt, partner with Arkwright.



414.—Apparatus for "drawing" Cotton.



415.—Carding-engine for Cotton.

416.—Distaff-spinning. (From Montfaucon.)

There is a machine called a *gin* very much used in cleaning cotton in America. In its simplest form it consists of two or three fluted rollers set in motion by the foot in the manner of a turning-lathe, and by its means one person may separate and cleanse sixty-five pounds per day; whereas in mere picking by hand, as is generally done by the Hindoos, only one pound a day can be cleansed. The larger machines used in the United States are much more powerful, and act in the following manner:—They consist of two wooden rollers about an inch in diameter, placed horizontally and in contact. Over them is fixed a sort of comb, having iron teeth two inches long, and nearly an inch apart; this comb is of the same length as the rollers, and so placed that its teeth come nearly in contact with them. When the machine is set in motion the rollers are made to revolve with great rapidity in opposite directions; so that cotton, being laid upon them, is by their motion drawn in between the two, whilst no space is left for the seed to pass with it. To detach these from the fibres of cotton in which they are enveloped, the same machinery which impels the rollers gives to the toothed instrument above a gentle oscillating movement, by means of which the pods of cotton as they are cast upon the rollers are torn open, just as they are beginning to be drawn in; the seeds, now released from the coating which had encircled them, fly off like sparks to the right and left, while the cotton itself passes between the cylinders. The sharp iron teeth of the comb moving with great velocity sometimes break the seeds, and the fragments are drawn in between the rollers with the cotton: these stray particles are afterwards separated by hand, a process which is called *moting*.

Some of the coarser kinds of cotton in Georgia were originally cleansed by *bowing*, or agitation with a bow-string; and in the market the term of "bowed" cotton is still used, although the cotton is now cleansed by other means. The bowing process is still carried on in many parts of the East, in the manner shown in Fig. 406. Abel, speaking of the Chinese bowing instrument, says:—"It is a very elastic bow with a tight string. In using it the carder places it in a heap of the material, and having pulled down the string with some force, he suddenly allows the bow to recoil; the vibration of the string scatters the cotton about, and separates it into fibres freed from knots and impurities."

The *saw-gin* (Fig. 403) is another contrivance for separating the seeds from the fibres, adapted for a particular kind of cotton which could not be cleaned conveniently in any other way. The American inventor, Mr. Whitney, had to suffer much of that unfair treatment which so often falls to the lot of inventors. Dr. Ure says that Whitney, "having spent a winter in completing his machine, showed a few friends that it could separate more cotton from the seed in one day by the labour of one man than could be done by the existing methods in a month. The construction of this instrument was an event of such consequence as to excite a universal interest in the state of Georgia, where Mr. Whitney then lived in narrow circumstances, under the roof of an hospitable friend. Neither the sentiments of justice nor the fear of the law could restrain the eager crowd from breaking into his workshop by night and carrying off his wonder-working tool. In this dishonourable way the public acquired possession of Mr. Whitney's invention before the model was finished to his mind, and before he could secure the protection of a patent. Many copies were immediately made from it with slight variations, in order to evade the patent which he obtained for it soon afterwards. Thus the inventor of a most ingenious machine was not suffered to reap in peace a reasonable share of the fruits of his labours, which proved so beneficial to his country." The machine here alluded to is provided with a number of circular saws, so placed that when the cotton passes down through an opening into which it is placed, it is caught by the teeth of the revolving saws, and disentangled.

Whatever may be the mode adopted, when the cotton is cleaned, it is packed into bags for shipment. The Sea-island cotton is packed in hempen bags made of Scotch sack-cloth, forty-two inches wide in the web, weighing about a pound and a half to the yard. Each bag is capable of holding on an average about three hundred pounds of cotton. The room into which the cleaned cotton has passed is set apart for the packing operation, and is kept free from dust. Adjoining to it is a small room under the same roof, with a round hole in the floor just large enough to contain the bag when full of cotton. The open end of the bag is fastened by twine to a wooden hoop which extends beyond the hole, so as to hang the bag upright by its mouth. A man then gets into the bag with a heavy wooden or iron pestle in his hands. Cotton is put in, which he first presses down with his feet, and then beats with the pestle, so as to make it occupy as little space as possible. In this way two men proceed, assisting each other, until the bag is filled.

Instead of this method, which much resembles that of packing or bagging hops in this country, cotton is sometimes compressed into bales in a more dense manner. A wooden cage is filled up, consisting of several square frames piled over each other, and then fastened together at the corners by moveable bolts. The cavity thus formed has the same area as the base of the bale, but is of a weight about four times as great as that of the intended bale, to admit a sufficient bulk of cotton in its loose uncompressed state. The bottom of the cavity has an ascending movement given to it by an hydraulic press; and the cotton becomes compressed into a hard bale by the gradual ascent of this board, the cotton being compressed at the top by a fixed board, and at the sides by the succession of frames. There is a provision for tying up the bale with ropes while still in the press. So great is the condensation produced by this method, that half a hundredweight of cotton is compressed into a space very little exceeding a cubic foot.

The bags and bales, so packed, are shipped from various ports in America and elsewhere, and brought mainly to Liverpool, whence they are dispersed to the various manufacturing districts.

Preparing the Imported Cotton for Spinning.

We have thus watched the growth, gathering, cleaning, and packing of the raw material which is destined to give employment to so many hundreds of thousands of persons in the preparation of garments; and we must now suppose the bales and bags to have arrived at Liverpool, and to be consigned to the hands of the dealers and brokers.

The bags having been sold to a manufacturer, whether in Manchester or any one of the neighbouring towns, they are opened, and the cotton classified according to its qualities, to suit the different kinds of yarn to be prepared from it. Although the fibres form very light locks or tufts when they have been cleaned from the seeds in America or India, yet they are so powerfully compressed in the process of packing, that the tufts become matted and entangled, and require opening before anything else can be done; because, in all the subsequent operations, each fibre must be combined unbroken with others, to form the collected group or thread. This disentangling is effected in various ways, according to the quality of the cotton, or the general arrangements of the factory. The finest is often opened and picked out by hand, in the manner shown in Fig. 405. It is placed on a table covered with a kind of net or mesh-work, and, after being lightly beaten with slender rods, the knots and other impurities are removed by the fingers. Another mode of disentangling the fibres is by "scutching" them, that is, spreading them out on a springing or elastic table, and beating them by a series of parallel rods until the fibres are disengaged.

But the most usual mode of effecting this opening disentanglement is by the use of some kind of rotating instrument called a *willow*, of which different forms are shown in Figs. 407, 411, 412. In the first of these there is a cylinder (seen separately in the lower part of the cut) having several teeth or spikes on its surface, and capable of revolving within a kind of case or box very near another series of spikes. A door is opened, and a boy or man puts in an armful of cotton, and closes the door again. The cotton is then thoroughly disentangled by being caught between the teeth during the rotation of the cylinder, and the dust and impurities fall through a kind of sieve to the bottom of the machine. After it has been worked about for a few seconds, the boy opens the door, removes the cotton which has been disentangled and cleansed, and puts in a new supply. Another willow, used in Normandy (Fig. 411), consists of an open cylinder, placed in an inclined position with an opening at which cotton can be introduced in it. The cylinder is made to rotate, and while the cotton descends gradually to the lower end, it is caught and tossed by spikes within the cylinder. The most complete machine, however, is such a one as that sketched in Fig. 412. There is a cone revolving within a cylindrical case; on the surface of this cone are a number of points or spikes; and the cotton, when disentangled by this means, is let out of the machine, and deposited in an equable layer.

When the fibres become completely opened, and all the dust and dirt is carried off by a powerful current of wind, excited for that purpose, matters are then ready for that highly curious series of processes in which the cotton is combed, carded, or straightened out in the manner requisite to form thread or yarn. This is in the first instance brought about by some such comb-like instrument as those shown in Figs. 408, 409, 410; or rather, as the teeth are here only seen sideways, we should say that each instrument is a kind of *brush*, having a large number of wire teeth fixed in a board or handle. In one of the figures (Fig. 408) it is seen that each tooth consists of a piece of wire bent into the form of a staple, and then having an angle or elbow made in each leg of the staple. These teeth are fixed into a very smooth and straight piece of leather, by holes pierced for that purpose; and very great care is taken that the angle at which the teeth lie should be the same throughout. When the proper number of these wires are fixed to the leather, the whole is called collectively a *card*. The making of these cards is now conducted by one of the most elaborate machines ever used in art. It straightens the wire from a coil, cuts off a piece of sufficient length, bends it into a staple-form, gives the angle or elbow to each wire, pierces the holes in the leather, and inserts the wires—the machine perfecting in this manner four or five hundred teeth in a minute!

In employing the cards two sets of teeth are made to act on opposite sides of the fibres of cotton. If two cards be placed as in Fig. 410, the one over the other, and the teeth inclining in the same direction; and if further a tuft or lock of cotton be placed between them, and the cards be moved in the direction of the arrows, then the cotton will be subjected to a twofold action. The upper teeth will endeavour to draw them in one direction, while the lower will pull them in another: the tuft will thereby be separated and drawn asunder in such a manner as to lay the fibres in some degree parallel, instead of being all confusedly heaped up together. If the cards be arranged, as in Fig. 409, with their teeth inclining in opposite directions, then the tendency is for each card to "doff" or sweep off the cotton fibres from the other; and it is on some such principle as this that the cotton is removed from the carding-machines. Originally the cards were made flat in form, and were worked against each other by hand or by machinery; but in the more improved mode of proceeding there are several cylinders placed near together (Fig. 415), each covered externally with cards, and by the rotation and mutual action of these cylinders the cotton becomes combed out so as to assume a tolerably even and parallel arrangement.

The fibres being thus partially regulated, they are fitted to undergo the next process—that of *drawing*. The intention of this operation is to draw out or elongate the fibres, so as to make them less densely and compactly heaped together. In the most efficient carding-machines the cotton is not only combed out parallel, but is brought to the state of flat ribands or "slivers;" the drawing attenuates these ribands, thereby making them thinner, longer, and more delicate. Many of the ribands are combined into one, and then drawn out, by which inequalities of thickness and quality are removed. The machine by which this is effected (Fig. 413) has two rollers, one above another, the upper one being smooth and covered with elastic leather, while the lower one is fluted longitudinally. There are three pairs of these rollers, the lower roller of each pair being fluted, and the upper one plain. The pairs are ranged side by side at such a distance, that as soon as the delicate fibre of cotton has passed between one pair, it is seized by another. The action, then, is this:—If these rollers revolved with equal velocity, the only effect produced in the cotton would be to flatten it; but if the second pair revolve faster than the first, and the third faster than the second, the cotton will be elongated or drawn out in its passage. The second pair of rollers have a tendency to catch the fibres faster than they are liberated from the first pair, and therefore elongate them to make up the deficiency; and the very act of pulling or drawing the fibres in this way also has the effect of straightening and laying them parallel. In Fig. 414 some of the working parts are shown as if separated from the rest of the machinery, to exhibit the action more clearly; the cotton first passing, from the cans between the rollers 1, 1; then between 2, 2; then between 3, 3; then through a funnel which collects them all; afterwards through another pair of rollers; and lastly falling into a can or cylinder.

The cotton, thus drawn out into a delicate riband, is next brought to the form of a still more delicate cord, called a "roving," by machines, of which three different kinds are seen in Figs. 421, 422, 423. The mode in which this is effected is very similar to that of "drawing," inasmuch as it draws out the cotton to a state of still greater attenuation; but as the cotton, in its now reduced thickness, has scarcely cohesive strength enough to make the fibres hold together, the roving or roved cotton has a slight twist given to it, by which it is converted into a loose kind of thread or spongy cord. Many forms of apparatus have been used for this purpose. In the one called the "can-roving frame," the cardings, coming from two upright cylindrical cases or vessels, and passing between two pairs of rollers, become elongated, and fall into another can, which by its rotation lays the roving in a coil, and at the same time twists it slightly. Another contrivance is the "jack-roving frame," in which the revolving case contains a bobbin whereon the roving is wound as fast as it is made. Next succeeded the "bobbin-and-fly frame," a machine which has undergone a remarkable number of changes and improvements from time to time. This kind of machine consists of a system of vertical spindles, on each of which is placed a reel or bobbin, and also a kind of fork called a "fly," still further removed than the bobbin from the axis of the spindle. The drawing or delicate riband of cotton is first drawn through or between rollers, and elongated to the state of a roving; then this roving passes down a tube in one prong of the fork, or fly, and becomes twisted by the revolution of the fly round the bobbin, while at the same time the twisted roving becomes wound with great regularity upon the bobbin. The

machine, in fact, performs three distinct operations: it first attenuates the "drawing" to a state of still greater thinness and delicacy than it had before; it then gives to the "roving" thus produced a slight twist, sufficient to enable the fibres to cohere; and lastly, it winds this twisted roving upon a bobbin, on which it is conveniently transferred to the spinning-machine. These bobbin-and-fly frames, with the improvements introduced in modern times, are among the most complex machines in the cotton manufacture. A modification of this machine, called the "tube-roving frame," produces a much larger quantity of roving in a given time; but the roving produced is fitted only for inferior purposes.

Here, then, we arrive at the stage in the processes immediately preceding that of spinning. We have seen that the operations carried on in the cotton districts have for their object the cleansing of the fibres from the seeds and other impurities; that the earlier processes in our own manufactories disentangle the fibres and range them parallel one with another; and that a further series are intended to form light and delicate ribands with these fibres, and then to transform these into fragile and slightly coherent threads called "rovings." The spinning of yarn from these rovings is the operation to which the inventions of those distinguished men (three of whose portraits are given in Figs. 404, 417, 418) who flourished sixty or seventy years ago, had chiefly relation: it was indeed the great point which led to the establishment of the factory-system in Lancashire. This will, therefore, be a convenient time to draw a comparison between the methods pursued by the Hindoos and other primitive nations, and the astonishing factory arrangement which has sprung up around us within the last seventy years.

The Hindoo Mode of Preparing and Spinning Cotton.

That the cotton goods made in India long preceded those of England in point of time, we have abundant evidence. Defoe, about a hundred and forty years ago, made the following condemnatory remarks on the use of cotton goods, deeming it an injury to our home manufactures that such should be the case:—"We saw our persons of quality dressed in Indian carpets, which, but a few years before, their chambermaids would have thought too ordinary for them; the chintzes were advanced from lying on their floors to their backs, from the foot-cloth to the petticoat; and even the Queen herself at that time was pleased to appear in China and Japan, I mean with China silks and calico. Nor was this all, but it crept into our houses, our closets and bedchambers; curtains, cushions, chairs, and at last beds themselves were nothing but calicoes or Indian stuffs; and, in short, almost everything that used to be made of wool or silk, relating either to the dress of the women or the furniture of our houses, was supplied by the Indian trade."

In India, women of all castes prepare the cotton-thread for the weaver, spinning the thread on a piece of wire, or a very thin rod of polished iron with a ball of clay at one end; this they rotate with the left hand, and supply the cotton with the right; and the thread in this state is wound upon a stick or pole. This is the primitive "distaff" spinning, of which a sketch, taken from Montfaucon, is given in Fig. 416. But for coarser kinds of yarn, the Hindoo females employ a simple form of spinning-wheel (Fig. 424), in front of which they sit on the ground. The cotton is cleaned for them by men who use the bowstring, as before mentioned. The bow is made of bamboo, and is fastened by strings to the wall of the room, at a height of about five feet from the floor. To the middle of this bow a card is tied, to which a second bow is attached of a larger size, strung with thick catgut; this second bow hangs about two feet above the ground. The man sits down, lays hold of it with the left hand, and strikes the string of the bow with a strong ebony stick held in his right hand; the vibration of the string causes the cotton to fly about and become loose and disentangled.

From a manuscript account of the Hindoo cotton manufacture, written by Dr. Buchanan and quoted by Dr. Ure, several interesting details may be gleaned. A good deal of the cotton is freed from the seed by the women who spin it, and a part of this is also beaten or "battened" by the same persons; but there is a class of men called Dhûniyas, who make a profession of cleaning and beating cotton. Perhaps one-third of these have stock enough to enable them to buy a little cotton, which they clean and then retail; but the greater number work entirely for hire. In many places these men are paid for their services in grain instead of money. "In every division," says Dr. Buchanan, "I procured an estimate of the proportion of women who spin cotton, of the average quantity of cotton that each spins, and of the value of the thread. Such estimates are liable to numerous objections; but it is probable when a number of them are taken, that the errors of the one will be nearly corrected by those of the others, so that the average will not be far from the truth. Allowing that the women of an age fit to spin are one-fifth of the population, the estimates that I procured will give for the whole thus employed 330,426 spinners (this relates to the provinces of Bahar and Patna). Now by far the greater part of these spin only a few hours in the afternoon; and, upon the average estimate, the whole value of the thread that each spins in the year is nearly 7r. 2a. 8p." If this alludes to the rupee equal to rather more than two shillings, the amount is sufficiently small; but it is well known that the money-value of labour in India is so small as to be hardly conceivable by workpeople in this country. Indeed it is stated that the spinners of the very finest yarns earn only about three farthings per day for their labour.

The delicacy of the Hindoo organization enables the spinners and weavers to produce good and exquisite fineness. Orme mentions an example in relation to the silk-twisters of Bengal, which is of the same character as that often observable in cotton-spinning. These women wind off the raw silk from the pod or cocoon; a single pod is divided into twenty different degrees of fineness; and so exquisite is the feeling of touch, that while the thread is running through their fingers, too swiftly for the eye to follow it, they will break it off exactly as the quality changes, and determine on the instant which among twenty different qualities is that at which they have arrived. The fineness of the muslin made by them from cotton has been the theme of many stories. Tavernier relates that a Persian ambassador, on his return from India, presented his king with a cocoa-nut, which contained a muslin turban thirty yards long, and so fine as hardly to be felt when expanded in the air. A broad web of some of their muslins may be drawn through a finger-ring.

The cotton, when spun by the Hindoo women, is delivered to the winders, who are chiefly young wives and girls, and who wind it into a skein or hank. Next comes the process of warping, by which the threads are ranged parallel for the weaver; and afterwards comes the weaving, of which in connexion, or rather contrast with English weaving, we shall have to speak further on. All these persons, in an earlier period of the East India Company's history, were employed by the Company in a curious way. The Company advanced, through their Residents at the different states, not only the cotton, but the funds required for the support of the workman and his family. The Resident had under him a number of subordinate officers; who, in their turn, had control over a corps of native clerks and inspectors. The Resident sent out to the native merchants proposals as to the kind and quantity of the goods required, and the merchants negociated with the workpeople as to the terms on which their fabrics should be supplied. The Resident gave the money and materials to the merchants, who were accountable for the due return of the produce, and the merchant distributed them to the workpeople. The Resident never interfered in the arrangements, unless any disputes arise between the contractors and the workpeople; in which case he sent his native overseers to settle any differences. When the weavers were not occupied by the government, the Resident used often to engage their services on his own account; and this system sometimes gave rise to abuses which required correction from head-quarters.

Respecting the peculiar *natural* fitness of the Hindoos for this kind of work (when not competed against by machinery) Dr. Ure remarks:—"In Coromandel, and in the province of Bengal, it is rare to find a village the least retired from the public road, where every man, woman, and child is not employed in making a piece of cotton-cloth. There are many districts in Asia and its islands equally propitious to the growth of cotton as Bengal, where the sun is as sultry and the people as unwarlike; yet this elegant branch of industry has hardly an existence among them. A more just cause for its exceeding prevalence in Southern Hindostan is the peculiar delicacy of tact of the natives of that region, for as much as they are deficient in mere muscular strength, so much are they endowed with exquisite sensibility and pliancy in every organ and limb. The hand of an Indian cook-maid is more delicately formed than that of a European beauty. An English workman could scarcely manage to work a piece of canvass with the simple loom with which the Gentoo weaves his gossamer muslin. His calling receives encouragement from public estimation. A weaver is there no ignoble caste, upon which patrician Hindoos can look down with disdain. He takes rank next to the scribe, and above all other mechanics. Were he to condescend to the performance of any drudgery out of the line of his business, he would lose his caste. This distribution of labour is of very ancient date. Every peculiar kind of cloth is the production of a peculiar district, in which it has been fabricated from generation to generation by certain races of men, each continuing to practise with minute precision the process of his predecessor. Thus it was their fine physical organization, guided by hereditary industry and experience, which gave to Hindostan the monopoly of the cotton trade for at least three thousand years.

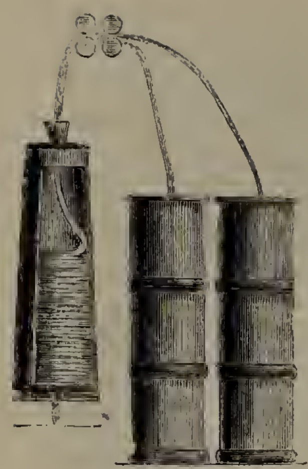
The Early State of Cotton-Spinning in England.

A comparison between these simple and stationary arrangements of the Hindoos, and the mighty energies of the English system, develops very notable results. So wonderfully perfect has the machinery become, and so great the skill displayed in every part of the manufacture, that the Manchester manufacturers can pay for the importation of the raw cotton, for the process of manufacture, and for the expense of shipment to foreign parts, and yet undersell the Hindoos, who spin for three farthings a day!

Before we notice the immense factories of the present day, it will be well to glance at some of the steps by which the system has been brought about. Dr. Aikin, in his 'History of Manchester,' separates the manufacturing system into four periods or epochs: the first, anterior to about the year 1690; the second, from thence to about 1730; the third from the year just named to Arkwright's time; and the fourth, subsequent thereto. During the first period, the manufacturers worked hard for a living, without accumulating any capital; and Aikin supposes there were few or none of them who possessed so much as three or four thousand pounds. During the second period, the manufacturers began to acquire small fortunes, but worked as hard and lived in as plain a manner as before, increasing their fortunes as well by economy as by moderate gains. They began to build modern brick houses, in place of those of wood and plaster; and they had dealings with wholesale firms in London, Bristol, Norwich, Newcastle, and Chester. "An eminent manufacturer of that age used to be in his warehouse before six in the morning, accompanied by his children and apprentices. At seven they all came in to breakfast, which consisted of one large dish of water-pottage, made of oatmeal, water, and a little salt, boiled thick, and poured into a dish; at the side was a pan or basin of milk, and the master and the apprentices, each with a wooden spoon in his hand, without loss of time dipped into the same dish, and thence into the milk-pan; and as soon as it was finished, they all returned to their work. In George I.'s reign, many country gentlemen began to send their sons as apprentices to the Manchester manufacturers."

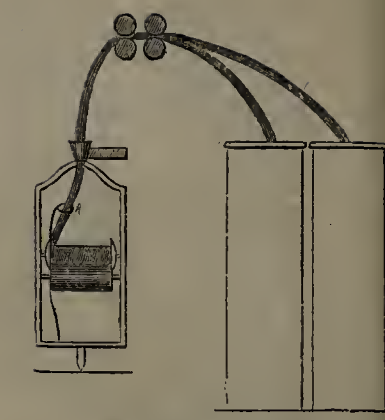
During the third of these four periods, the manufacturers greatly extended the mode of conducting their dealings with the merchants. Before that time the chapmen or dealers used to keep gangs of pack-horses, and to drive them to the principal towns with goods in packs, which they opened and sold to shopkeepers, depositing the unsold goods in small stores at the inns, and taking back sheep's wool to the manufacturing district. By degrees, however, turnpike-roads were improved; waggons instead of pack-horses were laden; and the chapmen only rode out for orders, carrying with them patterns in their bags. In the second period, country districts were supplied from the five or six large towns which received goods direct from Manchester, each serving as a centre to the surrounding country; but now the manufacturers began to send their riders to every part of the kingdom, soliciting orders. The fourth period or epoch was consequent on the introduction of machinery into the manufacture. The trade became so large, that manufacturers in commercial towns went to reside in London or on the Continent; foreigners and London merchants sent agents to reside permanently at Manchester; agents, factors, and brokers were established, some at Liverpool and some at Manchester, to manage the transactions between the merchants of the one town and the manufacturers of the other, both in respect to the raw cotton and the manufactured goods; all the manufacturers around Manchester agreed to make that town their mart, and to appoint certain days of the week as "market-days" with each other; and Manchester became, what it has ever since continued, one of the wealthiest towns of the empire.

Throughout three of these four periods the cotton manufacture was not strictly consistent with its name; for the "warp" or long threads of fustians and other varieties of cotton goods were made of linen, no mode being then known of making these threads strong enough of cotton. It was not until Arkwright's spinning-frame (Fig. 245) came into use that cotton-warps were made fitted for such purposes. While this mixture of cotton and linen continued, the mode of manufacture partook much of the domestic system observable in India. The weavers lived in country spots, where they could make gardening alternate with weaving. The cotton employed for the "weft," or cross-threads, was picked and cleaned by his younger children, carded and spun by his wife and eldest daughters, and woven by himself and his sons. As a good weaver could work up as much yarn as three efficient spinsters could spin, the weaver had often to go from house to house, buying yarn wherever he could get it. The manufacturers of Bolton or of Manchester used to give out the linen-warp to the weaver, and leave him to provide the cotton-weft, and to weave the two into cloth; and, by the terms of the agreement, he incurred a penalty if the woven cloth was not returned by a certain day. Mr. Guest says that a weaver was often under the necessity of trudging three or four miles in a morning, and visiting many spinners before he could collect weft enough to keep his loom going during the rest of

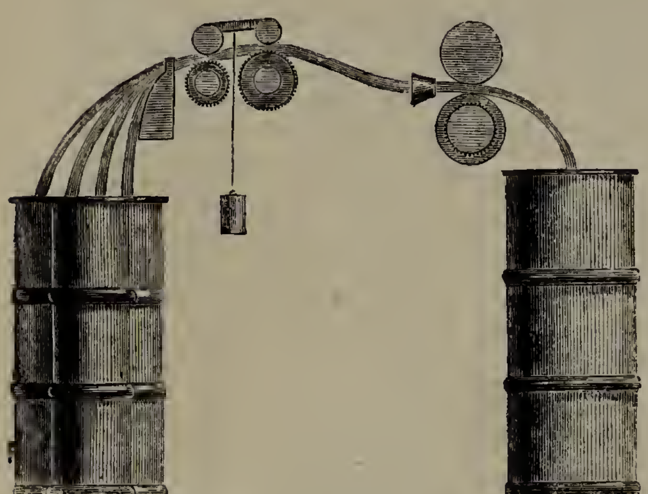


421.—The roving of Cotton.

419.—Cotton Factory near Stockport.

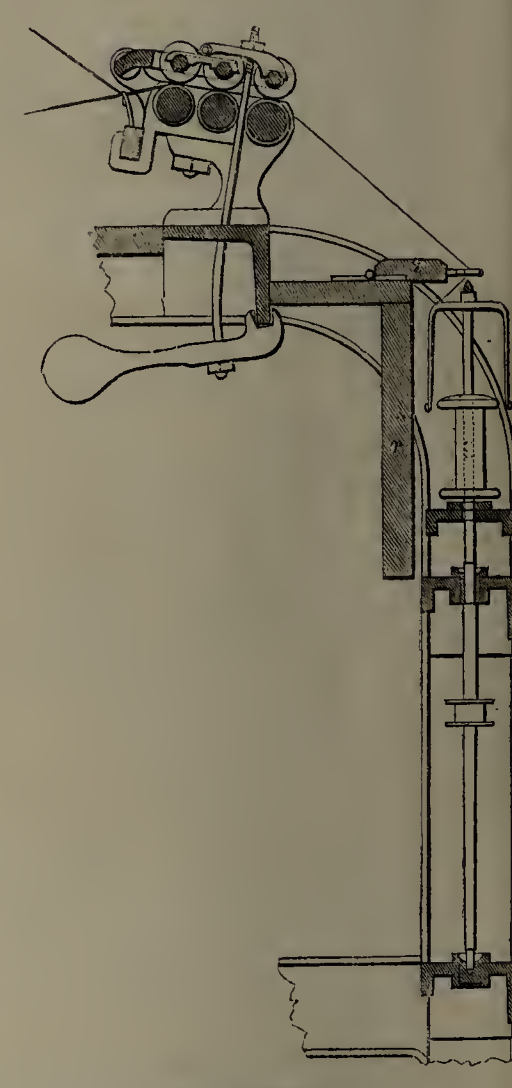


422.—The roving of Cotton.



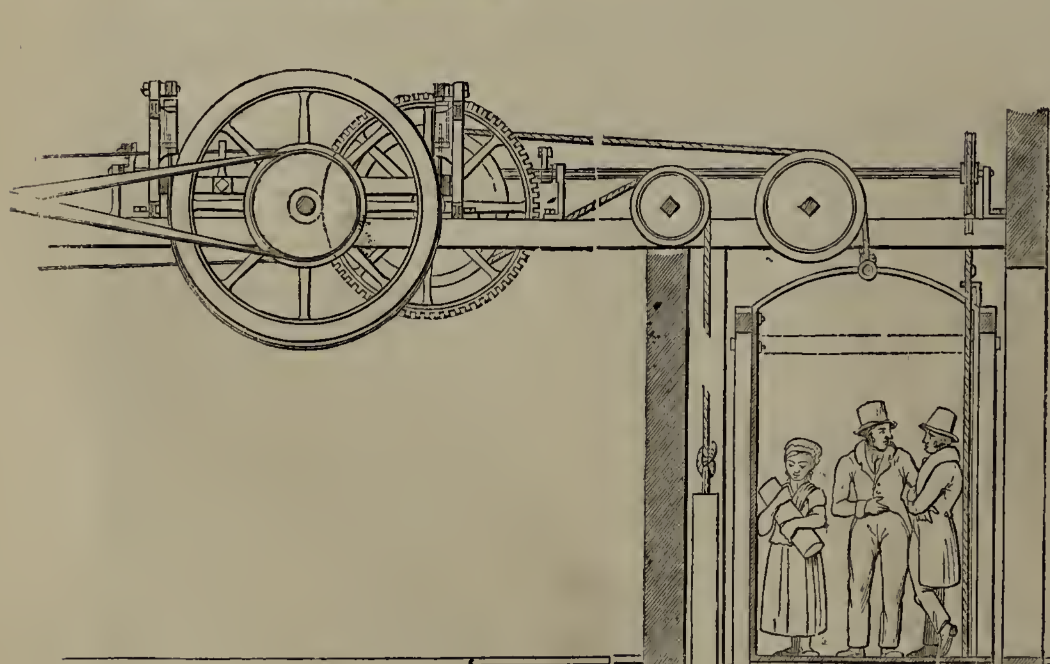
423.—The roving of Cotton.

418.—Samuel Crompton, inventor of the Spinning-mule.

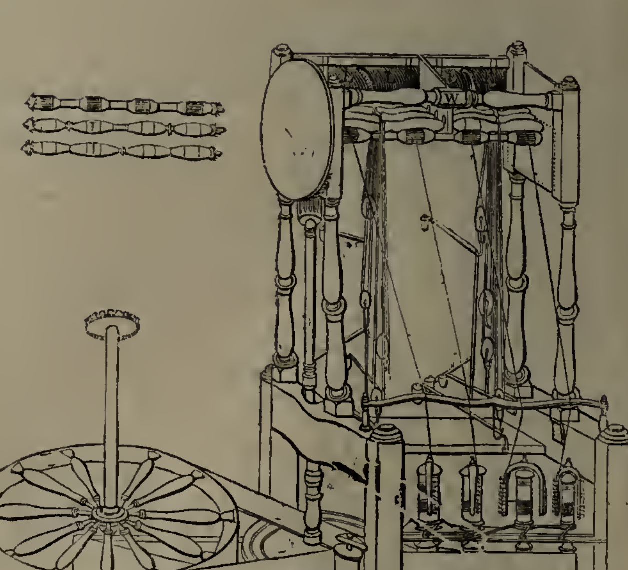


426.—Throstle Spinning.

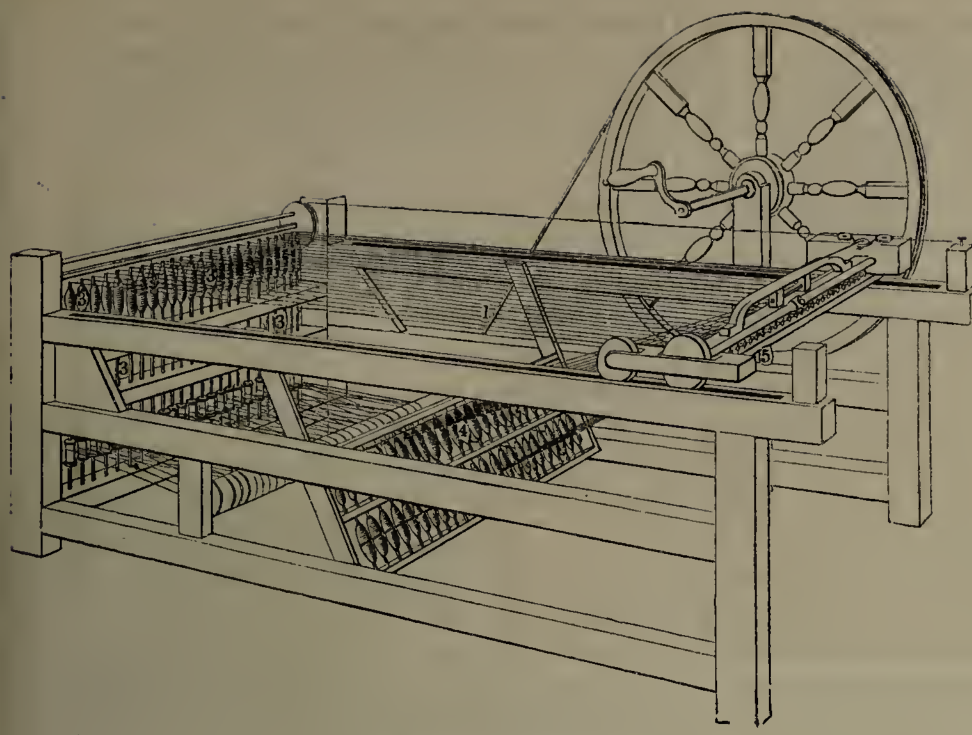
424.—A Hindoo Woman spinning Cotton.



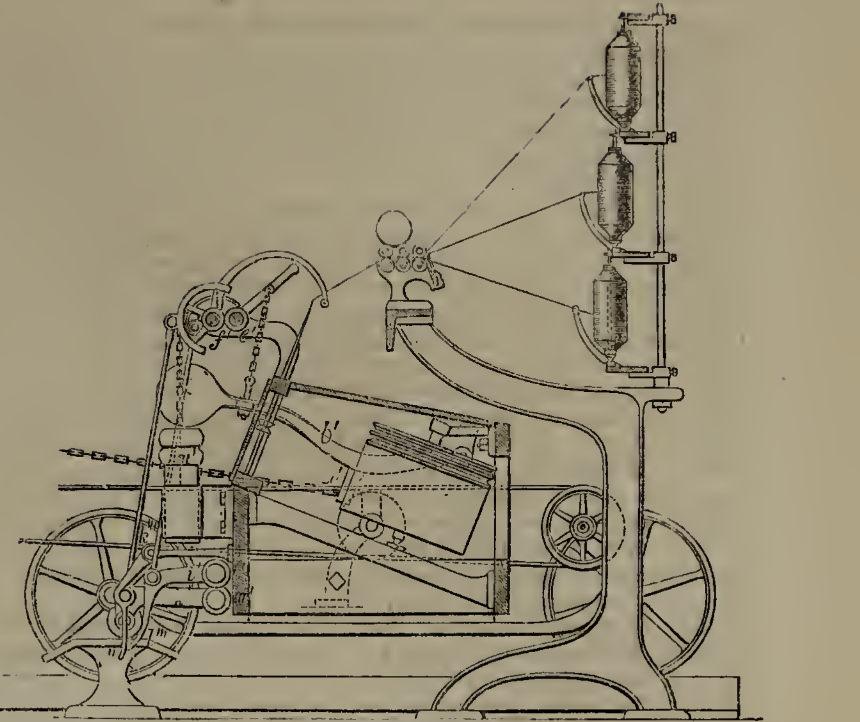
420.—The Teagle, or Factory Staircase.



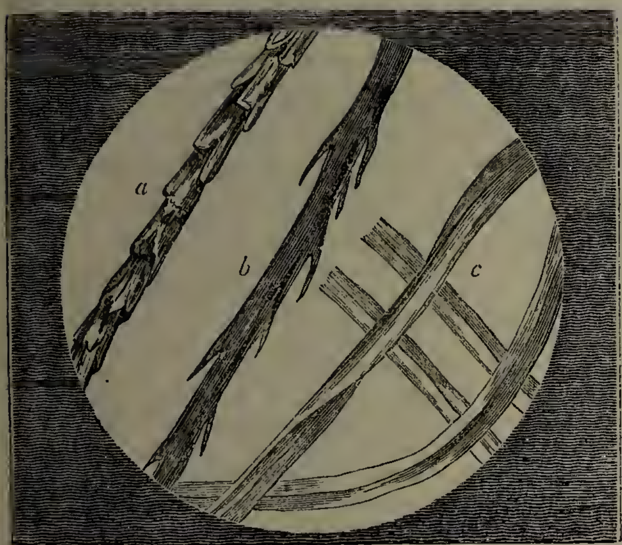
425.—Arkwright's original Spinning-machine.



427.—Hargreaves' Spinning-jenny.



429.—Self-acting Spinning-mule.



431.—*a*, Hair of Seal; *b*, Hair of Tiger-caterpillar; *c*, Filaments of Silk: magnified.

432.—Sir Thomas Lombe's Silk-mill, Derby.

428.—Cotton Mule-spinning.

430.—Hanks of Silk: *a*, Bengal; *b*, Italian; *c*, Persian; *d*, Broussa.

the day; and such was the competition which he met with from other persons having a similar errand, that he frequently had to fee and make presents to the spinners to allow him to be the purchaser. In short, the weavers were quite at the mercy of the spinners; and would, probably, have continued so but for the invention of Arkwright.

This extraordinary man—whose descendant, in an intervening period of only about seventy years, became nearly, if not quite, the wealthiest man in Europe—was the greatest among a small number who brought the cotton-manufacture to high perfection. Arkwright (Fig. 404), Strutt (Fig. 417), Crompton (Fig. 418), Hargreaves, Kay, and a few others, mostly of humble origin, all contributed to this important work. Arkwright was born at Preston in 1732. He was brought up as a barber, which occupation he carried on at Bolton till about the year 1760. His first effort in mechanics was an attempt to discover the perpetual motion—an abortive project which has occupied so many persons in the earlier season of their career in such studies. Observing the great scarcity in the supply of cotton-yarn for weaving, owing to the slow method of manufacturing it, Arkwright turned his attention to the matter, with the view of devising some mode of remedying the evil. In the course of his inquiries after some person qualified to assist him in making the movements of his first projected machine, Arkwright became acquainted with a clockmaker named Kay, with whose aid he carried out many of his ideas. In 1767 he gave himself up wholly to inventions connected with the cotton manufacture; but he was so poor that he could not decently appear at an election for Preston, until the person for whom he voted had given him a suit of clothes! Shortly after this, Arkwright went to Nottingham, where he fortunately met with encouragement from Mr. Strutt, who had made some improvements in the stocking-frame. Strutt had been a farmer, and, like Arkwright, had got into a different line of occupation from the force of mechanical genius. A patent was taken out for Arkwright's invention, Strutt finding the capital; and factories were established for "roller-spinning" on his method. The first mill erected was at Nottingham, and worked by horse-power; but in 1771 another was built at Cromford, near Matlock in Derbyshire, in which the machines were worked by water-power. It was from this circumstance that the machine employed by Arkwright was for a long time called a "water-frame," and the yarn spun by it "water-twist." This was the foundation of Arkwright's prosperity. He had to contend against numerous infringements of his patents; but he surmounted all difficulties by his unconquerable perseverance; he invented machines applicable to almost every part of the manufacture, and became a partner in a large number of factories in different places. He was in fact the father of the factory system, and had to devise arrangements necessary for the management of a number of persons in one place. By the year 1792, when he died, he had amassed a fortune of half a million sterling, and had opened a field of industry to which a large number of manufacturers directed their attention.

A few years before Arkwright began his career, James Hargreaves, a poor weaver of Blackburn, made an improvement in the common spinning-wheel, whereby it became much more effective than before. He had a large family to support by his earnings, and was in very straitened circumstances. It is said that happening to observe one day a spinning-wheel overturned upon the floor, and that the wheel and spindle continued to revolve, he was led to consider what would be the effect of placing the spindle perpendicularly instead of horizontally. He devised a mode of arranging several spindles in a row, so that they might all be made to revolve by the turning of a single wheel, and thereby to spin several threads at once. His new machine he called (or it was soon called by others) a "spinning-jenny;" and he kept his invention a secret for some time, using it only to make weft for his own loom. But his wife, having more vanity than prudence, talked of her husband's ingenuity to some of her neighbours; and the neighbouring spinners, becoming alarmed lest their trade should be injured by the new machine, broke into Hargreaves' house, destroyed the machine, and forced him to leave the place. He went to Nottingham, where he entered into partnership with another individual, and took out a patent for his invention; some flaw in the patent prevented him from reaping all the benefit from his ingenuity which he deserved; but the spinning-jenny became extensively used for making weft-yarn, in the same way as Arkwright's afterwards did for making warp-yarn.

Samuel Crompton (Fig. 418) was another of these benefactors to the cotton manufacture; and one, too, like the others, who had to suffer no small share of annoyance for his ingenuity. Crompton was a farmer's son, in a village of Lancashire, and was employed when young as a weaver. At the age of sixteen he learned to spin upon one of Hargreaves' "spinning jennies," then recently brought into use. Being dissatisfied with the quality of the yarn he produced, he began to consider how he might alter and improve the machine. He devoted five years to the attempt, and at length produced that modification of the machine which has been called the "spinning-mule," and which was the foundation of the finer kinds of cotton manufacture in this country, such as muslins. Like Hargreaves, he wished to keep his invention to himself, and to make yarn from it with his own hands; but as he got a better price for his yarn than other people did, his neighbours suspected that he had some new kind of machine. They came from all the surrounding districts to try to steal a glimpse of his apparatus and mode of proceeding, and when he worked in his garret they procured ladders, and looked in at his window. At length, tired out with this inquisitiveness, and not having the means of securing the invention to himself, he disclosed his secret to about fifty persons, who agreed to give him a guinea a-piece for it. The method thus became known generally, and was soon practised extensively. Crompton, about the beginning of the present century, had a sum of five hundred pounds presented to him by some gentlemen of Manchester; and ten years afterwards Parliament gave him a reward of five thousand pounds, as an acknowledgment of the extensive service which his machine had rendered.

The Cotton-spinning Factories of Manchester and the surrounding District.

It was mainly by these three machines—the "spinning jenny" of Hargreaves, and the "spinning-mule" of Crompton, for weft; and the "spinning-frame" of Arkwright, for warp; together with the "power-loom" of Dr. Cartwright (of which we shall have to speak farther on)—that the cotton manufacture rose in England to so unprecedented a height, and in such a short space of time. The steam-engine of Watt, too, gave power which nothing else could have supplied, to set all these machines in motion. M. Dupin, in an address which he delivered to the Working-classes of Paris some years ago, alluded to these matters in a very eloquent manner:—"Watt improves the steam-engine, and this single improvement causes the industry of England to make an immense stride. This machine represents, at the present time, the power of three hundred thousand horses, or of two millions of men, strong and well fitted for labour, who should work day and night without interruption, and without repose, to augment the riches of a country not two-thirds the extent of France. A hairdresser invents, or at least brings into action, a machine for spinning cotton; this alone gives to British industry an immense superiority. Fifty years only after this great discovery, more than one million of the inhabitants of England are employed in those operations which depend, directly or indirectly, on the action of this machine. Lastly, England exports cotton, spun and woven by an admirable system of machinery, to the value of four hundred millions of francs yearly. The Indies—so long superior to Europe—the Indies, which inundated the West with her products, and exhausted the riches of Europe—the Indies are conquered in their turn. The British navigator travels in quest of the cotton of India—brings it from a distance of four thousand leagues—commits it to the operation of Arkwright's machine, and of those that are connected with it—carries back their produce to the East, making them again to travel four thousand leagues: and in spite of the loss of time, in spite of the enormous expense incurred by this voyage of eight thousand leagues, the cotton manufactured by the machinery of England becomes less costly than the cotton of India spun and woven by the hand near the field that produced it, and sold at the nearest market. So great is the power of the progress of machinery." These numbers and quantities have been in every way vastly increased since the time when Dupin wrote this address.

As soon as it was found that one machine could do as much work as several men, and that one steam-engine could supply motive-power for several machines, the advantages at once became apparent of assembling a large number of machines together in one building, and of setting them in motion by one large steam-engine. Hence arose the system of building such immense factories as are to be seen in Lancashire, Cheshire, and Yorkshire. One of these (Fig. 419) will give a good idea of the generality of them. This building extends from end to end nearly three hundred feet, and has six ranges of windows, each range giving light to one story or floor of workshops. Taking the entire circuit of the building, on all the four sides, there are nearly a hundred windows in each story, amounting to about six hundred in the whole. The chimney presents rather a picturesque appearance, being placed on rising ground apart from the factory; the smoke from the furnaces being conveyed under the roadway to this chimney. In most such factories the upper stories are devoted to the opening, picking, willowing, and otherwise preparing the cotton fibres; the middle stories are devoted to the spinning; while the lowest are the "weaving-galleries," where the power-looms are at work. This does not however always apply. Some factories are applied only to the spinning of fine yarns, on the principle of Crompton's machine; some for spinning strong yarns for warp, on Arkwright's system; some combine both kinds of spinning in one building; some factories are for weaving as well as spinning; while others do not embrace weaving within the range of the operations. But wherever weaving is carried on, the looms are generally arranged on the ground floor or story.

Some of these large factories are very comfortably arranged in respect to the accompanying dwellings for the workpeople; especially in the more open districts at some distance from Manchester. At Hyde, on the southern side of the Mersey, is a factory or group of factories, the arrangements of which were thus spoken of in a pamphlet by Dr. J. P. Kay, a few years ago:—"Twelve hundred persons are engaged in the cotton factories of Mr. Thomas Ashton of Hyde. This gentleman has erected commodious dwellings for his workpeople, with each of which he has connected every convenience that can minister to comfort. He resides in the immediate vicinity, and has frequent opportunities of maintaining a cordial association with his operatives. Their houses are well furnished, clean, and their tenants exhibit every indication of health and happiness. Mr. Ashton has also built a school, where six hundred and forty children, chiefly belonging to his establishment, are instructed on Tuesday in reading, writing, arithmetic, &c. A library, connected with this school, is eagerly resorted to, and the people frequently read after the hours of labour have expired. An infant-school is, during the week, attended by two hundred and eighty children, and in the evenings others are instructed by masters selected for the purpose. The factories themselves are certainly excellent examples of the cleanliness and order which may be obtained by a systematic and persevering attention to the habits of the artisans."

A very curious contrivance has been introduced for facilitating the ascent and descent of these lofty factories. It is called a *teagle* (Fig. 420), and is intended to avoid both the fatigue and loss of time in passing from one floor to another of these buildings. The teagle consists of a moveable platform enclosed in an upright tunnel or shaft, situated in some convenient part of the building: it is usually of such size and stability as to allow half a dozen persons to stand on it at once, and to be transported either upwards or downwards. The perpendicular shaft has a horizontal section or area about five or six feet square, and extends from the ground-story to the top floor. The platform is suspended by ropes from pulleys, so as to be moved up and down by machinery: it is bounded by a strong framework of timber on three sides, leaving the front side open, in correspondence with a series of doors on the several floors of the factory. The power required for hoisting is moderated by the use of two counter-weights, together about a hundredweight heavier than the platform: the weights ascend when the platform descends, and *vice versa;* so that the machinery has not such a heavy load to draw up as it otherwise would have. Two large planks are fixed upright upon the opposite walls of the shaft, as guides to the platform, and two smaller ones as guides to the counter-weights. There are ropes which can be pulled by the person or persons on the platform. When one of these ropes is pulled, the wheel-work at the top is brought into such a position as to raise the platform; when the other rope is pulled, the platform is lowered by the machinery; and by the management of the ropes the ascent or descent is stopped at any one of the stories, according as the travellers may require. The movement of this locomotive platform is very smooth and easy.

Such are a few of the principal features presented by the factory arrangements of the cotton manufacture—a system which was thus strikingly illustrated by Dr. Taylor two or three years ago:—"The History of the cotton manufacture in England is without a parallel in the annals of any age or country. In the beginning of the reign of George III. it gave employment to forty thousand persons, and the value of the goods produced was 600,000*l.* (yearly); it now employs not less than fifteen hundred thousand persons, and the value of the goods produced exceeds 31,000,000*l.* It is difficult to form a conception of the extent of such a manufacture; but the following calculations may help our readers to an intelligible idea of its vastness. The cotton-yarn annually spun in England, would, in a single thread, girdle the globe 203,775 times; it would reach fifty-one times from the earth to the sun; and it would encircle the earth's orbit eight times and a half. The wrought fabrics of cotton exported in one year would girdle the equatorial circumference of the globe eleven times. The cotton manufacture furnishes one half of British exports, employs one-eleventh of our population, and supplies almost every nation in the world with some part of its clothing. The receipts of the merchants and manufacturers from this simple branch of industry, equal two-thirds of the public revenue of the kingdom." And the same writer also puts in a forcible light the *suddenness* with which this great system has developed itself:—"The factory system is a modern creation; history throws no light on its nature, for it has scarcely begun to recognise its existence; the philosophy of the schools supplies very

imperfect help for estimating its results, because an innovating power of such immense force could never have been anticipated. The steam-engine had no precedent; the spinning-jenny is without ancestry; the mule and the power-loom entered on no prepared heritage; they sprang into sudden existence like Minerva from the brain of Jupiter, passing so rapidly through their stage of infancy, that they had taken their position in the world, and firmly established themselves, before there was time to prepare a place for their reception. These potent novelties also made their appearance in a land already crowded with institutions: the force and rapidity with which they developed themselves dislocated all the existing machinery of society, disturbed its very framework, and must necessarily produce, as they have produced, a considerable amount of confusion and suffering, until the difficult task of re-adjustment is completed. A giant forcing his way into a densely-wedged crowd extends pain and disturbance to its remotest extremity; the individuals he pushes aside push others in their turn, though none know the cause of pressure save those with whom the intruder is in immediate contact; and thus also the factory system causes its pressure to be felt in districts were no manufactures are established: all classes are pressed to make room for the stranger, and all are interested in knowing something of what is thus forced upon their acquaintance."

The Process of Spinning Cotton.

We have given in this place the above short view of the origin of the factory system as applied to the cotton manufacture; because it was especially in relation to the process of spinning that the system had its origin. We may now, therefore, proceed to notice this operation.

It must be clearly borne in mind what is the object of spinning. The "rovings" of cotton being slender loose cords, having very little strength, they require, before they can be used as yarn for the weavers, to be twisted round their centre until all the fibres are so curled as to form a tolerably firm thread. In the early distaff-spinning, the fibres were drawn out of a bundle by the fingers, and spun at the same time without any of the elaborate processes of the modern manufactures; but the wheel furnished a better means. A spinning-wheel (without attending to minor differences) acts in the following manner:—The spinster sits on a stool, and takes in her lap a bobbin containing cotton-roving. Unfastening one end of the roving, she attaches it to the end of a horizontal spindle, which is so connected to a large wheel as to be set in rotation by it. The spinster, holding the cotton in her left hand, draws her hand back some distance from the spindle, and, by turning the wheel with her right hand, twists the portion of cotton extending from the spindle to her left hand. When this is twisted into a tolerably fine yarn, she winds it on the spindle by reversing the motion of the wheel. The main principle in this operation consists in this: that by stretching out a portion of the cotton, and causing the revolving of the spindle, to one end of which it is attached, the other invariably receives a twist, which condenses and hardens the assemblage of fibres. The wheel occupies the fore-finger and thumb of both hands, those of one hand holding the filaments, while those of the other draw the filaments out into an equal thread. Sometimes two spindles are attached to the wheel, and the spinster can then form a thread with each hand.

There is a very remarkable legend current both in Germany and in Ireland respecting the origin of the spinning-wheel; showing that the importance of the invention, as a means of saving time and labour, was well appreciated by those who were not much accustomed to trace events to their origin. The German version of the story is contained in a collection of popular legends by Grimm; while the Irish is given by Dr. Cooke Taylor (in his 'Handbook of the Cotton, &c. Manufactures'), as he took it down from the recital of an old woman famous for her skill in storytelling.

The story runs thus.—"Once upon a time" an old woman and her daughter lived at the side of a hill in the midst of a forest. They were very poor, and their only source of support was the thread which the daughter spun with her spindle and distaff. During the long winter, when the roads were so bad that the merchants could not come round to purchase the thread, the daughter worked incessantly, in order that she might have enough of thread, when the spring market came, to purchase a red cloak for her mother and a snood for herself, that they might go in proper attire to their devotions. It so happened that the prince, the king's son (there are always "princes" ready made for popular stories, whether chronology will have it so or not), while hunting, came near the old woman's cottage. He was struck with the daughter's beauty, and also with the numerous hanks of yarn lying in the cottage. In reply to a question from him, the old woman, as a means of setting off her daughter's industry to advantage, said that it had all been spun in one week. "In a week!" exclaimed the prince: "if this be true, I have found a wife more worthy and valuable than any other in the country. I will send you a load of flax, and if she has it spun by the end of the week, I will choose her as my bride; but if not, I will have you both cut in pieces and thrown to the dogs for deceiving the son of your sovereign." The poor girl was stricken with dismay at this result of her mother's imprudence; for she knew that she could not spin so much thread in a week with her distaff and spindle. On the following day a long train of pack-horses laden with flax came before the door of the cottage; and the drivers, having unloaded them, told the girl that she must spin this quantity in a week, or prepare for death. While she was weeping over her hard fate, a decrepit old man came up to her, and on hearing her tale, offered to execute the task for her, on condition either that she would give up to him her first-born son when a year and a day old, or else should discover his (the old man's) name. She consented; the old man took away the flax by some mysterious means; and, in an equally wonderful manner, brought back the whole spun into thread just before the fatal week expired. The prince came, found the task accomplished, and married the damsel. He gave her out, every Monday morning, an equal quantity of flax, and she, aided by the mysterious old man, presented it back in the form of thread at the end of the week. The newly-made princess, on the birth of a son, began to be uneasy about the terms of her agreement with the old man, for she had not yet found out his name. One evening, when she was oppressed with melancholy at the prospect, the prince returned from hunting, and told her that, while roaming through the forest, he heard a human voice, followed its direction, and came to a cave where an old man was spinning with wheels which "flew round as rapidly as lightning, and gave out thread like water falling from a mountain-torrent." The old man was singing a song, of which the prince remembered the following verse:—

> "Little my mistress she knows my name,
> Which shan't be forgot, which shan't be forgot,
> When a prince as heir to the fortunes I claim
> Of Wallotty Trot, Wallotty Trot."

The princess listened eagerly, and at once concluded that "Wallotty Trot" was the name of her mysterious visitor. When he next called, to claim the child according to the terms of the bargain, she guessed at his name; he said she was right. "You have indeed detected my name," said he, "and my business on earth is well nigh finished. Before I disappear, however, I am bound to tell you the secrets of my art." So saying, he went to the forest, and returned with the wheels. He taught the lady their use, showing her that she could spin seven times more with them than with the distaff; after which he disappeared, and was never seen again. The prince and princess taught this new branch of industry to their subjects, and so enriched the state that all the surrounding nations regarded them with envy and admiration.

This famous exploit of Wallotty Trot, made into a popular story among country people, is quite sufficient to show that, let the spinning-wheel have been invented when and where it may, its advantage over the old distaff and spindle is sufficiently appreciated by those who have most to do with such matters.

But the wheel itself gave way to the more comprehensive machines of Hargreaves and Arkwright, in the way we have before mentioned. In Hargreaves' machine there were placed eight rovings in a row, and in another part a row of eight spindles. The rovings when extended to the spindles, passed between a clasp which opened and shut, and thus loosened or held them. A certain length of roving being extended from the spindles to the clasp, the clasp was closed, and was then drawn along to a considerable distance from the spindles, by which the threads were lengthened and attenuated. This was done with the spinner's left hand, while the right hand turned a wheel which caused the spindles to revolve rapidly, and thus the roving was spun into yarn. By a further adjustment the yarn was wound on the spindle. This machine, in one of its later and more improved forms, is sketched in Fig. 427.

Arkwright's machine acted in a very different manner. The original form which it presented is sketched in Fig. 425. A more recent variation of the same principle, called the "throstle," has been introduced, of which a portion is seen in Fig. 426, just sufficient to show the action. In contrivances of this kind, there are bobbins containing cotton-roving, so placed as to revolve easily in a vertical position. By the rotation of these bobbins the roving is unwound; and after passing over a slender bar, is carried between some pairs of horizontal rollers, which, by a varying velocity, have the effect of drawing or stretching the cotton; the roving for each bobbin then passes down one prong of a curious kind of fork, called a "flier," and as this flier rotates round a little pin or bobbin, the cotton, which becomes firmly twisted by the rotation of the flier, is wound on the bobbin in the form of yarn. This is the general principle of a large variety of spinning-machines, whose differences lie in minor details.

It was the main object of Crompton's invention, the "mule," to combine the two qualities of the machines devised by Hargreaves and Arkwright. It was found that though Arkwright's machine could produce strong yarn for the warp, or long threads of cloth, it could not produce fine and delicate yarns: and Crompton thought that by a modification of the arrangements he could secure the advantages of both the others. We may as well, for shortness, speak of Arkwright's machine by the name which it long bore, the "water-frame;" Hargreaves', the "jenny;" and Crompton's the "mule." Like the "water-frame," then, the "mule" has a system of rollers to reduce or attenuate the roving; while, like the "jenny," it has spindles without bobbins to give the twist; and the thread is stretched and spun at the same time by the spindles after the rollers have ceased to give out the roving. The spindles in the "mule" travel to and fro in a carriage; whereas in the "water-frame" and the "jenny," the spindles are fixed in position. The elongation is performed, first, partially by rollers, as in the "water-frame," and then finished by the stretching action of the moveable carriage on Hargreaves' principle. In the "mule" there is a carriage which draws out five or six feet, bringing with it a large number of threads or yarns, which are stretched by this action, and at the same time are twisted by the revolution of the spindles to which they are attached. In the common "mule" this carriage is moved by the left hand of the spinner; but in the "self-acting mule" it is moved by machinery. In Fig. 428 is given a sketch of a room containing a number of large "spinning-mules;" while Fig. 429 shows some of the mechanism of a "self-acting" mule.

These two principles of action, in the two classes of machines, are kept up as much now as ever they were, according to the kind of yarn which is to be spun. Dr. Ure compares the two thus:—"The mule makes a definite length of yarn, after which it winds it up while the operation of spinning is suspended; whereas the throstle makes the yarn and winds it up simultaneously. The mule is used generally for all numbers above 30's (a technical name for a certain thickness of yarn); throstles being now seldom used to spin so high as 40's. The quality of the yarn produced by the two machines is quite different. The throstle-yarn, known under the name of "water-twist" (from having been first produced by the "water-frame"), is smooth and wiry; while the mule-yarn is of a soft and downy nature. The former is usually employed for warps in heavy goods, such as fustians, cords, or for making sewing thread; and the latter for weft in coarse goods, as also for both warp and weft in fine fabrics."

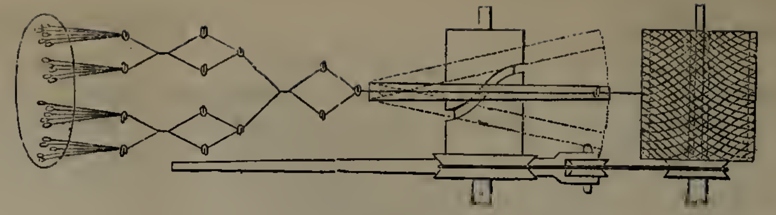
The numbers above named, as relating to the thickness of the yarn produced, are regulated in the following manner:—The spun yarn is always made up into hanks containing 840 yards; and the number affixed to that quality denotes the number of those hanks to form a pound. Thus No. 40 means yarn of which 40 hanks go to the pound, or of which the pound contains $40 \times 840 = 33{,}600$ yards; No. 60 implies 60 hanks to the pound, or that the pound contains $60 \times 840 = 50{,}400$ yards; and so on. The production of No. 80 was deemed a wonderful achievement of Crompton's apparatus, and he obtained two guineas per pound for yarn having that degree of fineness; but such have been the improvements since his day, that even a finer quality, No. 100, can be purchased for 3*s.* per pound; while the power of producing exquisitely fine yarn has advanced to such a degree, that as high a number as 400 has been produced! This extraordinary degree of fineness is such that the yarn of this number is not much thicker than the fibre of a spider's web—or at least it so appears to the eye. If we make a little calculation we shall find that four hundred hanks to the pound, with eight hundred and forty yards to each hank, gives a sum total of three hundred and thirty-six thousand yards, or very little short of two hundred miles of thread for one pound of cotton!

After the yarn has been spun, it is wound on a reel in measured lengths called hanks, in order to bring it into a convenient form for sale or shipment. The yarn, as collected on the bobbins in the spinning-machines, is in the form of "cops," and these cops are unwound in order that the yarn may assume the new form of hanks. There is a machine employed, containing an hexagonal reel a yard and a half in circumference, and also having a carriage upon which are mounted the bobbins containing the cotton. By a system of ingenious mechanism, the cotton is made to unwind from the bobbins, and to rewind on the reel. The reel strikes a check after every eighty revolutions, thereby indicating that a hundred and twenty yards of yarn have been wound on it; this quantity is called a *lay* or a *rap;* and seven of these lays form a hank of eight hundred and forty yards.

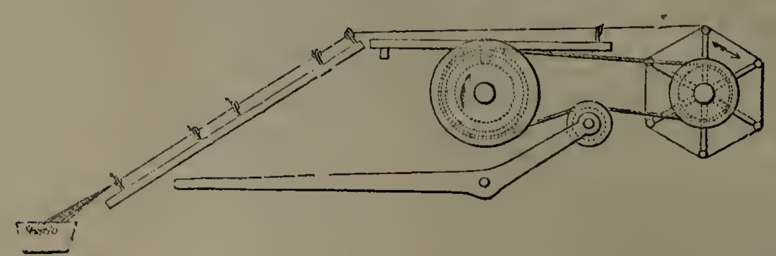
This yarn, then, is so far finished as to be ready for the operation of the weaver, the stocking-maker, or others by whom it is to be worked up. The quality varies greatly, according to the purpose to which it is to be applied; but the mode in which the cotton is brought to the state of yarn is always pretty much the same as we have now described.

Some of the yarn employed for making bobbin-net and hosiery requires to be "singed" before use, that is, to have the fine loose fibres burned off. This is

436.—Egyptian Winding-reel.

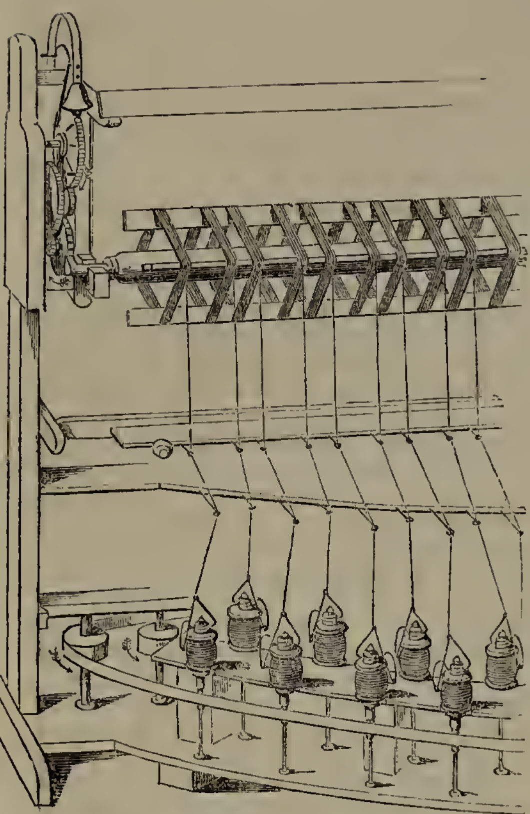


Plan.



Section.

433.—Reeling Silk from the Cocoons.

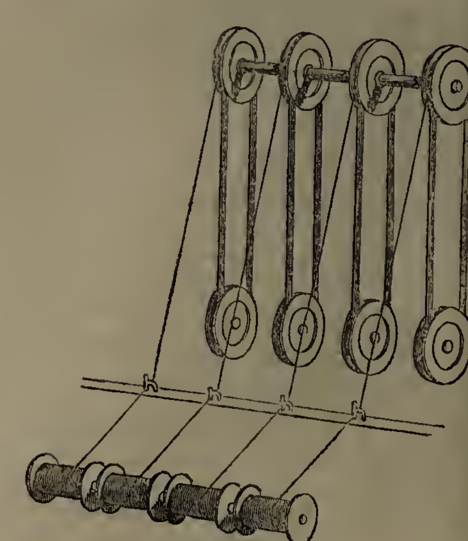


439.—Silk-throwing Machine.

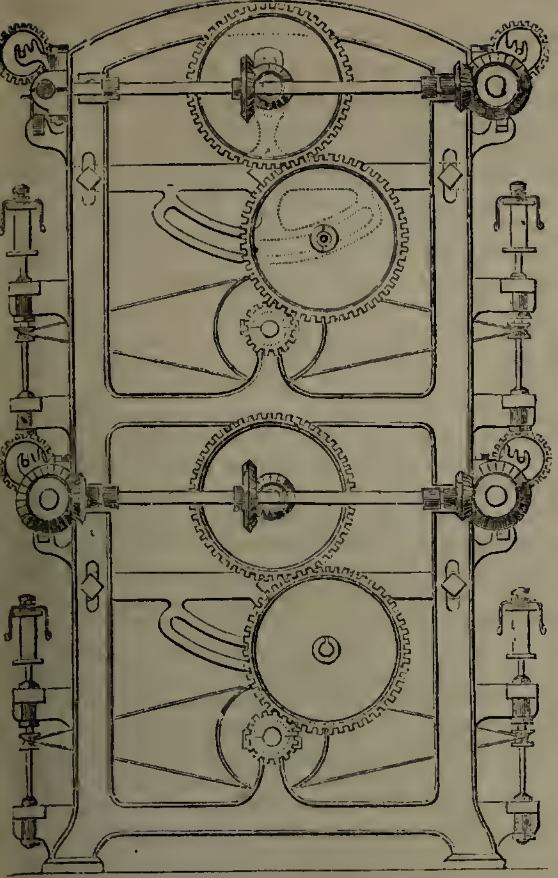
438.—Silk-doubling.]

437.—Silk spinning Machine.

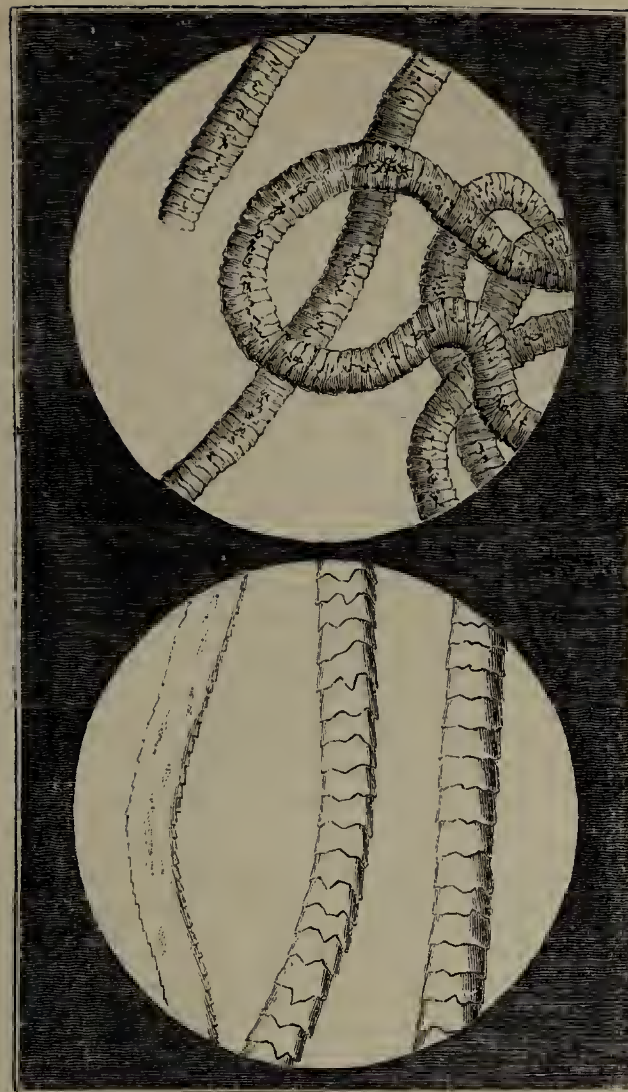
434.—Silk-winding Machine.



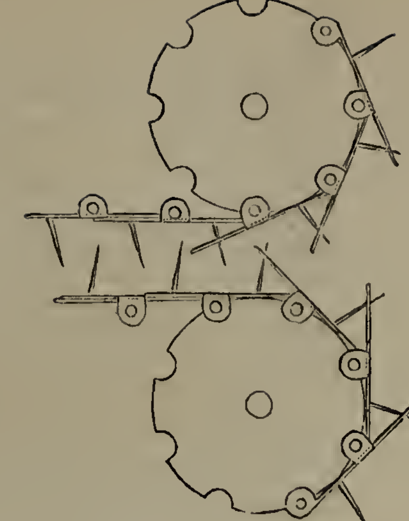
435.—Winding-engine.



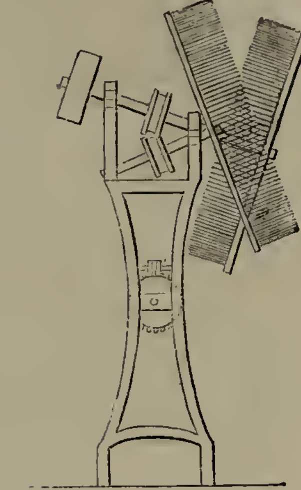
442.—Silk-spinning Engine.



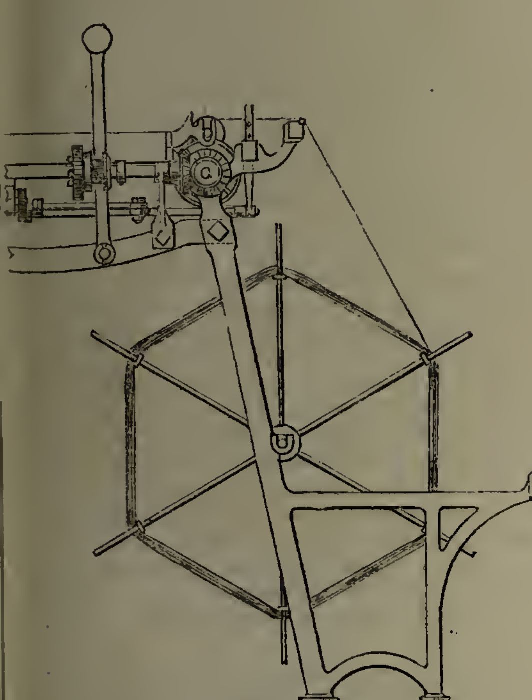
446.—Fibres of Wool, greatly magnified.



444.—Wool-combing Machine.

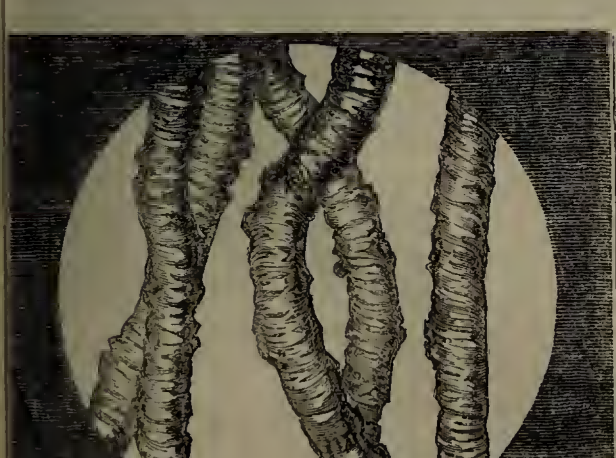


445.—Wool-combing Machine.



440.—Silk-engine, or Swift.

441.—Silk-throwing, or Spinning by Hand.



447.—Fibres of Wool, greatly magnified.

443.—Shawl-wool Fleece of the Cashmere Goat.

accomplished in a curious manner: the machine employed has a series of gas-flames or jets, through every one of which the yarn passes, the rapidity of movement being so regulated, that the loose divergent fibres may be burned off without endangering the substance of the thread itself.

The yarn of which we have been speaking is not strictly the *thread* familiar to most persons. It is too thin and weak to serve as sewing thread, and requires to undergo the processes of doubling and twisting in order to fit it for that purpose. Indeed, whether the thread is for sewing, for lace, or for hosiery, the yarn requires to be doubled and twisted to give it the necessary strength. Two or more yarns are doubled and twisted together; the number so doubled, and the fineness of the yarn, depending on the object in view. Sometimes, immediately before being doubled and twisted, the yarn is passed through a trough containing a weak solution of starch, by which the closeness and smoothness of the thread are improved. The twist is given in an opposite direction to that of the individual yarns, thereby presenting a similarity to the mode of making ropes from strands or smaller ropes. A doubling-machine is used, provided with a pair of rollers, for the purpose of delivering the yarns at a measured rate to the twisting-spindles. The actual process of twisting is so similar to that of spinning, in the general mechanical arrangements, as to need no particular description.

Having thus traced this important material, cotton, from the state of a delicate down in the seed-pod to the state of thread, we might next proceed to notice the mode of working it up into a usable form at the loom and at the bobbin-net machine, and of decorating it afterwards by dyeing, or printing, or embroidering. But it may perhaps be better to glance at the other three textile materials in succession, to trace them all up from their origin to the state of yarns or thread, and then to take up the subjects of weaving, of bleaching, of dyeing, of printing, &c., as applicable to all four, noticing, when necessary, the differences between them.

SILK: ITS PRODUCTION AND MANUFACTURE.

We will therefore transfer our attention to that very beautiful material which results from the labours of the silk-worm; labours constituting one of the most striking and interesting features presented to the study of the entomologist.

It is observable that the four great classes of textile fibres employed for the production of clothing, viz., cotton, silk, wool, and flax, are essentially different in their origin. They are all delicate filaments, but they present little in common as respects their formation. Cotton and flax are of vegetable growth, one proceeding from the seed-pod, and the other from the stem; wool and silk are of animal growth, one proceeding from the outer covering of the animal which produces it, and the other elaborated by a little insect from a glutinous substance within its body. That substances so dissimilar should all alike be brought within the power of the loom, and employed in the formation of beautiful cloth, is a fact strikingly illustrative of man's ingenuity, and seems to point to the probability that increased resources will be laid open to those who seek among the natural riches presented to our use.

Progress of Silk-rearing in different Countries.

The little silk-producing animal—first a worm, and then a moth—requires close and careful attention in order that the produce of its industry may be made available to man. It is to the Chinese that we owe the knowledge of this art; among whom it has been practised from very remote times. Long before the inhabitants of Europe knew that silk was produced from an animal at all, the manufacture of silken goods by the Chinese was known in Europe. The early Greek writers spoke of the lustrous beauty and brilliancy of the Asiatic robes; and in more than one passage alluded to China (or Seres, as it was then called) as the place whence they came. One of these writers, supposing that silk was a vegetable production, spoke of it thus:—

> "Nor flocks nor herds the distant Seres tend;
> But from the flowers that in the desert bloom,
> Tinctur'd with ev'ry varying hue, they cull
> The glossy down, and card it for the loom."

The introduction of silk-rearing into Europe was brought about in a manner partaking much of a romantic character. According to the received version of the story, two Persian monks in the time of Justinian, having been employed as missionaries in some of the Christian churches, found their way eastward to Seres or China. They there viewed with curiosity the usual dress of the Chinese, the manufacture of silk, and the myriads of silk-worms. They soon discovered that it was impracticable to transplant the short-lived insect, but that in the eggs a numerous progeny might be preserved and multiplied in a distant climate. They observed with interest the labours of the silk-worm, and strove to make themselves acquainted with all the manual arts employed in making up the material produced into so great a variety of fabrics. On their return to the West, instead of communicating the knowledge thus acquired to their own countrymen, they proceeded to Constantinople, the capital of Justinian's empire. They imparted to the emperor the secret, until then known only to the Chinese, that silk was produced by a species of worm; and acquainted him with their belief that the eggs of these might be successfully transported, and the insect reared in his dominions. They likewise explained to him the modes of preparing and manufacturing the slender filament, which had till then been a mystery in Europe. By a promise of a large reward, these men undertook to return to China, and there, by means of much precaution and with great difficulty, they succeeded in obtaining more silk-worms' eggs. These they concealed in a hollow cane; and at length, in the year 552, they conveyed them in safety to Constantinople. The eggs were hatched in the proper season by the warmth of manure, and the worms were fed with the leaves of the wild mulberry-tree. The worms in due time spun their silk; and the monks gave all the instruction in their power concerning the mode of manufacturing it into thread for the weavers. These silk-worms, if the narrative be correct, were the progenitors of all those which have since existed in Europe.

This department of industry was for more than six hundred years confined (so far as Europe was concerned) to the Eastern or Byzantine empire. It was not till about the time of the Crusades that it spread westward or northward. In the twelfth century silk-rearing began to be practised in Sicily, in the thirteenth century in Italy, in the fourteenth in Spain and France, and in the fifteenth in England. But this latter point, the introduction of silk-rearing into England, is more a matter of curiosity than of commercial advantage. It is now known that various circumstances, including that of climate, prevent the rearing of silk-worms from being profitably carried on in this country; but this fact was not known three centuries ago. James the First was extremely solicitous to promote this branch of industry in England; and the cultivation of the mulberry-tree (a necessary part of the proceedings, as we shall presently explain), was commenced in St. James's Park. Evelyn in his 'Diary,' under the date 13th of June, 1649, says, "Lady Gerrard treated us at Mulberry Garden, now the only place of refreshment about the town for persons of the best quality to be exceedingly cheated at: Cromwell and his partisans having shut up and seized on Spring Gardens, which till now had been the usual rendezvous for ladies and gallants at this season." In relation to this passage, a writer in 'London,' No. 11, remarks, "The Mulberry Garden was planted by order of James I., who attempted in 1608 to produce silk in England, and to that end imported many hundred thousand mulberry-trees from France, some of which were planted under his own inspection, and the rest dispersed through all the counties with circular letters, directing the planting of the trees, and giving instructions for the breeding and feeding of silk-worms. In 1629 a grant was made to Walter, Lord Aston, &c., 'of the custody of the garden, mulberry-trees and silk-worms, near St. James's, in the county of Middlesex.' How soon after this the silk-worms disappeared, and the gardens were opened to the gay world in the manner indicated by the above quotation from Evelyn, does not appear. He does not speak of the opening of the Mulberry Gardens as anything new."

During the reign of George the First another attempt was made of a similar kind. A company was incorporated, and empowered to obtain a lease for one hundred and twenty-two years of Chelsea Park; mulberry-trees were extensively planted, and large buildings erected for managing the rearing of silk-worms. But the enterprise failed; and all subsequent attempts (of which there have been many) to introduce silk-rearing into England, as into the United States, have been equally unsuccessful as commercial speculations; partly on account of climate, and partly owing to the higher rate of wages in these countries than in the South, the employment being such as can have very little aid from machinery. Even so late as 1835, a company was formed for this object in Ireland, but without success.

China, India, Italy, southern France, and Turkey, are the chief silk-producing countries, to which our manufacturers are indebted for their supply of this material.

Mode of rearing Silk-worms.

Mr. Porter states that the methods pursued by the Chinese in rearing the silk-worm are superior to those followed in Europe, and we will therefore borrow from his 'Treatise on the Silk Manufacture' a brief account of this department of Chinese industry.

In those parts of the empire where the climate is favourable to the practice, the silk-worm is allowed to remain at liberty, feeding at pleasure on the leaves of its native mulberry-tree, and passing through all its mutations among the branches, uncontrolled by the hand and unassisted by the cares of man, the *cocoons*, or balls of silk, being gathered when in a proper state, with the exception of those required to perpetuate the breed. The silk so produced, however, is found to be inferior in quality to that which is spun by worms under shelter, and whose growth and food have been carefully attended to. Much attention is therefore bestowed by the Chinese on the artificial rearing of the insects. One of the principal objects of care is to prevent the too early hatching of the eggs, to which the nature of the climate strongly disposes them. The mode of ensuring the requisite delay is, to cause the moth to deposit her eggs on large sheets of paper; these, immediately on their production, are suspended to a beam of the room, and the windows are opened to expose them to the air. In a few days the papers are taken down and rolled up loosely, with the eggs in them, in which form they are hung up again during the remainder of the summer and through the autumn. Towards the end of the year they are immersed in cold water, wherein a small portion of salt has been dissolved. In this state the eggs are left for two days; and on being taken from the salt and water, are first hung to dry, and then rolled up rather more tightly than before, each sheet of paper being afterwards enclosed in a separate earthen vessel. Some of the cultivators use a ley made of mulberry-tree ashes; and they also place the eggs for a few minutes either in snow-water, or on mulberry-trees exposed to snow or rain, where the climate permits of this being done.

These precautions are taken to prevent the silk-worms from being hatched before the season when the mulberry-leaves (their proper food) are in a fit state for them. When the proper time for the hatching has arrived, the rearer takes the rolls of paper from the earthen vessels, and hangs them up towards the sun, the side to which the eggs adhere being turned from its rays, so that the heat may be transmitted to them *through* the paper. In the evening the sheets of paper are rolled closely up and placed in a warm situation. The same plan is followed on the next day, when the eggs assume a greyish colour. On the evening of the third day, after a similar exposure, they are found to be of a much darker colour, nearly approaching to black; and the following morning, on the papers being unrolled, they are seen to be covered with worms. In the colder latitudes the Chinese have recourse to the heat of stoves to promote the hatching of the eggs.

The apartments in which the worms are kept are in dry situations, in a pure atmosphere, and apart from all noise, which is thought to be annoying to the worms, especially when they are young. The rooms are made very close, but with adequate means of ventilation. Each chamber is provided with nine or ten rows of frames placed one above the other; on these frames rush hurdles are placed, upon which the worms are fed and kept. A uniform degree of heat is constantly preserved, either by means of stoves placed in the corners of the apartments, or by chafing-dishes, which from time to time are carried up and down the room. Flame and smoke are carefully avoided. The most sedulous attention is paid to the wants of the worms, which are fed during the night as well as the day. On the day of their being hatched they are furnished with forty meals; thirty are given on the second day; and fewer on and after the third day. The Chinese have such a strong opinion that the silk produced depends on the quantity of food eaten, that when the appetite of the worms flags, from temperature or other causes, they contrive means to excite or stimulate it artificially.

The quicker the worm arrives at maturity, the greater is the quantity of the silk produced; and hence every care is taken to hasten its development. The changes which the little animal undergoes during this time are most remarkable. In the first place, the egg from which it is produced is about the size of a grain of mustard-seed, and the worm itself, when first hatched, is a little slender thread about a quarter of an inch long. During its growth it will wander about in search of food, but if mulberry-leaves be supplied to it in plenty, it will remain stationary, occupied during the early days of its existence almost wholly in eating. When it is about eight days old, its head enlarges, and the worm becomes unwell; it remains three days without food, and in a lethargic state. In fact, its growth has been so enormous, that its skin is too tight to enclose its bulky body; and this sickness seems to indicate the period when the old skin or envelope is abandoned, and gives way to a new one more consonant with the increased size of the animal. The process is a most extraordinary one, for the insect literally creeps out of its own skin head foremost; lubricating its body to assist the extrication, fixing the skin to a mulberry-leaf by filaments of silk spun from its mouth, and making its escape by slow degrees. The operation appears to be a painful one, for the little animals are observed to rest several times during its progress, and to be much exhausted on its completion.

When Nature has given it a more easy-fitting coat, the busy silk-worm proceeds to eat with great voracity, and increases to the length of half an inch in five days. The second coat has become by this time too small for the wearer, and is abandoned in the same manner as before. In its third stage the worm keeps on eating as before, increases in five days more to three-quarters of an inch in length, and then requires a third moult-

ing or enlargement of skin. Another period of five days elapses, a further enlargement to an inch and a half in length takes place, a fourth sickness supervenes, and for the fourth time the worm, finding its skin too tight for its bulky body, creeps out of it altogether, and enjoys a freer existence. This is now the fifth stage of its existence as a worm; and it proceeds to eat so voraciously (mulberry-leaves being still its favorite food), that in ten days it attains a length of two inches and a half or three inches.

The time now approaches when the silk-worm, having received so much food from its attendants, yields more than an equivalent in the form of silk. The worm ceases to eat, appears restless and uneasy, seeks about for some place where to spin its silk, and forms a sort of resting-place in some nook or corner. The body of the worm at this time contains a secretion which afterwards constitutes silk: it is a fine yellow transparent gum, contained in two slender vessels in the stomach. The worm spins or expels this gum from two small orifices in the head, uniting the two into one thread by a peculiar action of the mouth, and laying the silken thread thus formed in such a way as to build a hollow ball, nest, or "cocoon." The little spinner remains within his prison-house, building up around him a silken wall, and spreading and arranging the thread with his front feet in waving lines around him. In this way each worm spins about four hundred yards of delicate silken filament, which is arranged into a hollow egg-shaped mass, measuring about an inch and a half long by an inch in diameter.

When the cocoon is formed the insect smears the inner surface with a peculiar kind of gum, which is also used to make the silken thread cohere in making the cocoon. The animal has become by this time wasted and wrinkled, and then throws off its caterpillar state, assuming the form of a crysalis. It remains as a crysalis during a period of from fifteen to thirty days, and seems during this time to be preparing itself for its final stage of existence as a winged moth. When this stage is attained the moth softens the gummy interior of its house, and gradually works for itself a hole through the cocoon, emerging at length into open day as an active but short-lived moth.

It will thus be seen that the silk-worm goes through many remarkable changes. It is first confined within its egg; then it emerges as a worm; then casts its skin four different times, to accommodate its increasing bulk; envelops itself in a silken nest; then changes to a crysalis, the intervening stage between the worm and the moth; and lastly, assumes the usual appearance of a winged insect. Their increase in size, and the quantity of food devoured by them, are quite remarkable. Fifty thousand silk-worms, when just hatched, weigh only an ounce; there are only four thousand to an ounce at the period of casting the first skin; only six hundred at the time of the second moulting; only a hundred and fifty at the time of the third; only thirty-five at the time of the fourth; and when just ready to spin, six of them weigh an ounce; so that in the period of five or six weeks, the silk-worm increases in weight nine thousand-fold! Their voracity may be thus illustrated: the worms proceeding from one ounce of eggs will consume six pounds of mulberry-leaves before their first moulting; eighteen pounds between the first and second moulting; sixty pounds between the second and third; one hundred and eighty pounds between the third and fourth; and more than a thousand pounds between the fourth moulting and the period of spinning their silk: thus consuming, in six weeks, twenty thousand times their own weight of food!

Collecting the Silk from the Cocoons.

If the moth be left to itself it will live within its cocoon till a proper time, and then make for itself a means of escape; but when man chooses to appropriate the silk to his own use, he puts the little hard-working prisoner to death before its time. The cocoons are exposed to the heat either of the mid-day sun or of an oven, until the insect within is stifled. This being done, the external soft envelope is removed from the cocoon; the former constituting *floss-silk*, afterwards brought to the state of yarn by silk-spinning; and the latter being afterwards manufactured by silk-throwing. The three or four hundred yards of filament forming each cocoon are agglutinated together by a sort of gum applied to them by the insect; and it is necessary to soften this gum before the filament can be unwound from the egg-shaped ball. To effect this, a number of cocoons are thrown into a vessel of hot water, and there allowed to remain till the gum is softened. The reeler, or person employed, then takes in her hand a whisk, or kind of brush made of fine twigs, and presses its end gently on the cocoons. One filament from each cocoon adheres to the whisk, and is made to commence the process of unwinding. She thus gets between her fingers the thread of several cocoons, ten or twenty in number, and attaches them all to a reeling-machine. She groups them into parcels containing three or four each, then combines two of these parcels, then two of these larger parcels, and so on until all are combined to form one thread, very much thicker than the individual filament, but still an exceedingly fine thread. This thread she winds on a reel or hollow frame, replacing the spent cocoons by new ones and having the water of such a temperature as to soften the gum just as fast as the silk is required to be wound. This process is sometimes done with the apparatus seen in Fig. 433.

We may here remark that all the processes of silk-rearing, from the collecting of the eggs to the reeling of the silk, are illustrated by a series of remarkable drawings in the "Chinese Exhibition," which are well worth the notice of the visitors to that place. The drawings are executed in that minutely-detailed manner characteristic of the Chinese artist, objectionable on the point of broad pictorial effect, but valuable as illustrating the exact nature of each thing depicted.

When the silk, after being wound on the reel, is removed from it, it forms a *skein* or *hank*, which is fastened up in a convenient form to send to market. The relation which the quantity of silk bears to the number of worms may be thus shown: supposing each cocoon yields on an average three hundred yards of silk, then it has been estimated that the original silk filament, as produced by the insect, would require nearly five hundred miles of length to weigh one pound! Two hundred and fifty average-sized cocoons weigh about a pound; and eleven or twelve pounds of cocoons yield one pound of reeled silk, the other eleven-twelfths being made up of the weight of the crysalis, floss-silk, waste, dirt, &c. The number of insects thus required to produce any considerable weight of silk almost exceeds belief. Mr. Porter remarks:—"The quantity of silk material used in England alone, amounts in each year to more than four million of pounds' weight, for the production of which myriads upon myriads of silk-worms are required. Fourteen thousand million of animated creatures annually live and die to supply this little corner of the world with an article of luxury! If astonishment be excited at this fact, let us extend our view into China, and survey the dense population of its widely spread region, whose inhabitants, from the emperor on his throne to the peasant in the lowly hut, are indebted for their clothing to the labours of the silk-worm. The imagination, fatigued with the flight, is lost and bewildered in contemplating the countless numbers which every successive year spin their slender threads for the service of man." It has been calculated (and such a calculation is perhaps the best fitted to bring the matter home to familiar comprehension), that a "Gros-de-Naples" silk dress, of average size and quality, requires the labours of about *three thousand* of these little animals to produce the raw material!

The hanks of silk are of different kinds and appearance, according to the countries where they are prepared. A few specimens are sketched in Fig. 430. The silk has different tints, but all are of a golden and beautifully rich yellow, with minor variations. Broussa silk and Chinese silk are whiter than the other kinds; Bengal silk is made up into hanks or heads of small size; the Italian hanks are rather larger; the Persian, which are of inferior quality, are larger still, weighing about a pound each. These hanks constitute what is termed *raw-silk; thrown-silk* (which used to be largely imported when silk-throwing was not so much carried on in England as at present) being that which has been worked in the silk-mills.

Silk-Throwing.

The threads which form the hanks of silk are neither thick enough nor strong enough to be employed by the weaver or the sempstress. They are very fine, and the texture tolerably smooth. In Fig. 431, a comparison is shown between the microscopic appearance of silk and that of two other filamentous materials—the hair of the seal, and the hair of the tiger-caterpillar. These latter two present the teeth-like serrations which (as we shall have to explain when treating of wool) give rise to the *felting* property of hair and wool. Confining ourselves, however, here to silk, it is necessary to observe that the silken filaments, in order to be prepared for weaving or sewing, require doubling and twisting and hardening. This is the class of operations carried on in silk-mills or throwing-mills, of which the principal in this country are situated in Manchester and in Derbyshire. Silk-spinning is a distinct and more modern branch, of which we shall speak presently.

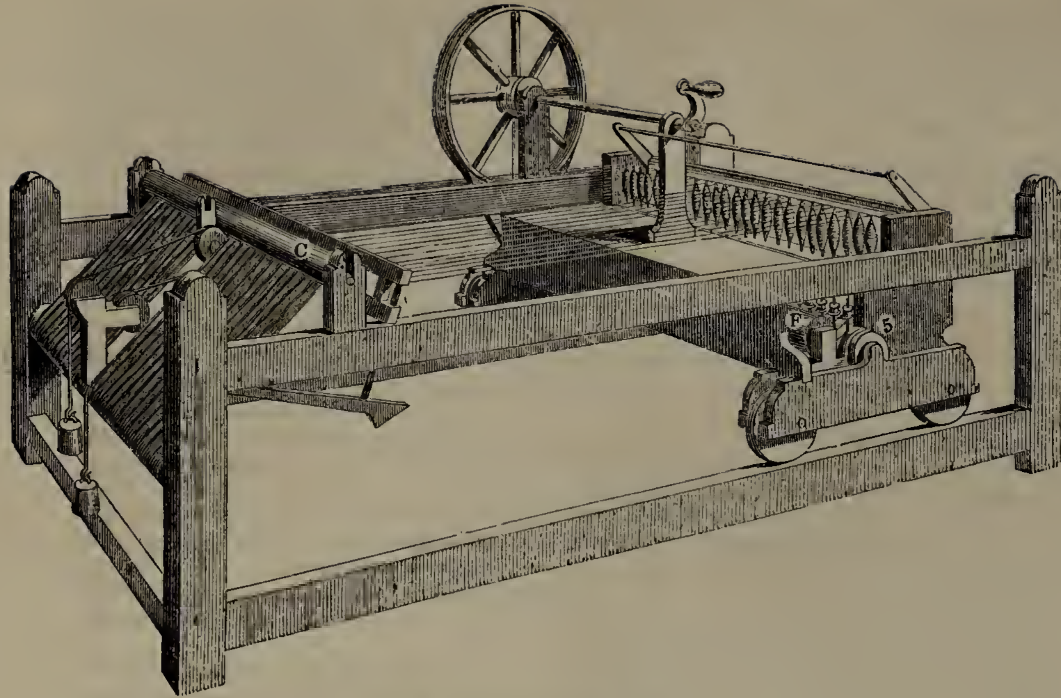
The introduction of silk-throwing into England was as remarkable in its way as that of silk-rearing into Europe. Until about the year 1700, all the silk woven in England was "thrown" or made into yarn in Italy; but at that time, a Mr. Crotchet, of Derby, attempted to introduce the art of silk-throwing into that town. He failed. John Lombe, a man possessed of much mechanical skill and determination of purpose, soon afterwards went out to Italy, with the view of learning the Italian method. He gathered, bit by bit, all the information necessary to his purpose; but at great personal risk; for the Italians would have resisted his attempt to the utmost, had they known it; and even with all his care he was obliged to escape precipitately from the country.

Lombe came to England, and agreed with the corporation of Derby to let him have a small plot of ground on the river Derwent, where he built the large mill depicted in Fig. 432. The earlier of these bold operations were planned and executed by John Lombe; but they were ultimately carried out by his cousin Thomas, afterwards Sir Thomas Lombe. The old mill has ever since been worked for the same object, and is so still; but it has changed owners many times. Concerning the death of John Lombe, the quaint but shrewd William Hutten, who worked at the old mill in the year 1730, gives the following account:—"Alas! he had not pursued his lucrative commerce more than three or four years when the Italians, who felt the effects from their want of trade, determined his destruction, and hoped that of his works would follow. An artful woman came over in the character of a friend, associated with the parties, and assisted in the business. She attempted to gain both the Italians (Lombe had succeeded in bringing two Italian workmen with him from Italy), and succeeded with one. By these two, slow poison was supposed, and perhaps justly, to have been administered to John Lombe, who lingered two or three years in agony, and departed. The Italian ran away to his own country; and madam was interrogated, but nothing transpired, except what strengthened suspicion."

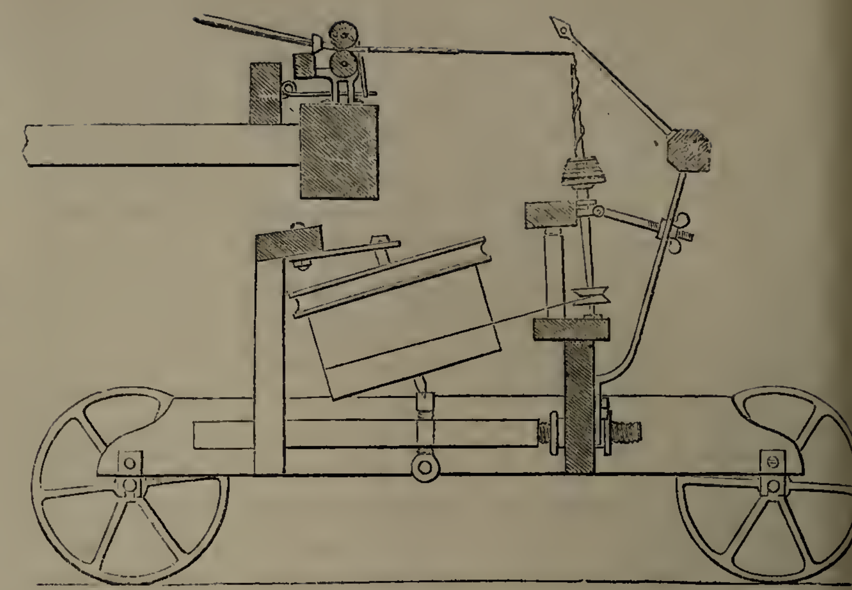
The processes through which the silk passes depend somewhat on the purposes to which it is to be applied. The names of *dumb-shingles, thrown-shingles, tram, organzine*, and *sewing*, are applied to five varieties of the thread. The first, consisting of silk merely wound and cleaned, is used in weaving gauze and other light articles; the second, after being wound, cleaned, and thrown, is used for weaving into ribbons and common silk; the tram, after being wound, cleaned, thrown, and doubled, is used for the weft of the best kinds of silk goods, such as velvets, gros de Naples, and figured silks; organzine is employed for the warp of the same goods which has tram in the weft; and sewings are silken threads brought to the proper state for the seamstress. The organzine has an extra degree of twist given to it; for after being wound, cleaned, and twisted in one direction, two or more threads are doubled together and twisted in the opposite direction, something like the strands of a rope. The various processes are repeated in varying order, according to circumstances; but they comprise chiefly *winding, cleaning, doubling*, and *twisting*.

The *winding* has for its object the transference of the silk from reels to bobbins. There is, in the first place, a four-sided or six-sided frame, called a "swift," on which the hanks of silk are wound after being opened; and several of these swifts are arranged in a row in a frame, as shown in Fig. 434. Above the reels are bobbins, four or five inches long. The swifts revolve on one axis, and the bobbins on another, and when a thread is brought up from each swift to the bobbin above it, and the bobbin made to revolve, it is easy to see that the silk will be removed from the swifts, and wound upon the bobbins. This, then, is the *winding*, and while it is going forward the *cleaning* is also effected, or else in a separate machine immediately afterwards. The cleaning consists in the removal of any impurities or irregularities by which the diameter of the thread may have been rendered unequal; and it is effected by passing the silk through a cleft in a piece of steel, so adjusted in size as to allow the thread, in its proper state of thickness, to pass freely through, but to detain all asperities and inequalities. The process of winding takes part in the preparation of many textile materials, and is carried out in various ways; thus, Fig. 435 shows part of a mechanical arrangement whereby yarn or thread is transferred from bobbins to the form of skeins, or from skeins to bobbins, as the case may be; while in Fig. 436 we see an Oriental arrangement of the winding process and apparatus; and in the next page of cuts, at Fig. 440, we have a section of one of the more complicated machines used in modern factories.

The twisting of a silken thread round its own axis, to give strength and uniformity, is effected by the aid of such machines as that shown in Fig. 437. There are two tiers of apparatus here combined, one above another; but the principle of the process will be best understood by confining the attention to one only. At the top are several bobbins ranged with their axes horizontal. At a distance of some inches below them are other bobbins ranged with their axes vertical, and the silken threads are conducted downwards from the former to the latter. There is a kind of loop or eye which aids in winding the thread equally on the vertical bobbins. Now the peculiar action of these two sets of bobbins, one upon another, is this: when both sets of bobbins are revolving, or rather, the upper bobbins and the loops of the lower ones, the thread becomes unwound from the upper ones, and wound upon the lower. But this is not all. In order that the thread may conform to the difference of rotation, first horizontally and then vertically, it becomes *twisted*, like the spiral form of a rope; and it is this twist which is the object of the process. If, while the upper bobbins maintain a regular rate of movement, the loops of the lower ones increase the rapidity of their rotation, the twist becomes harder, closer, or with a larger number



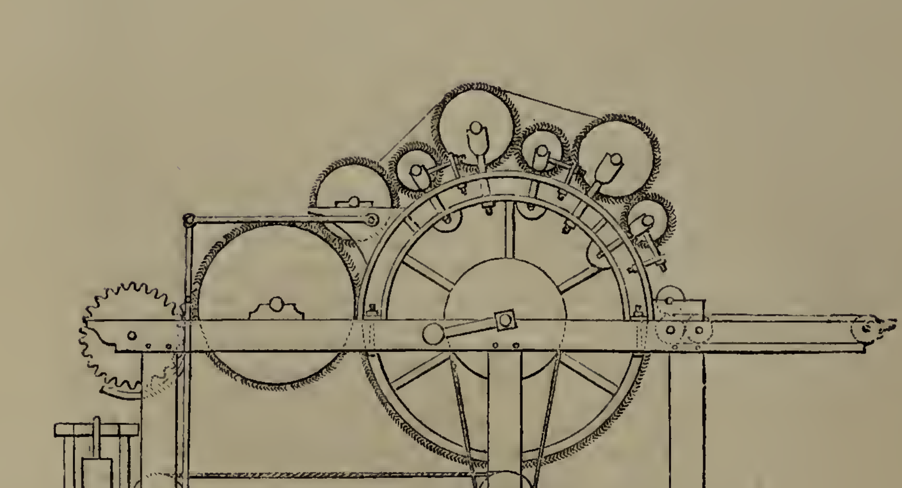
449.—The Slubbing-machine, or "Billy."



451.—Wool-spinning Mule.

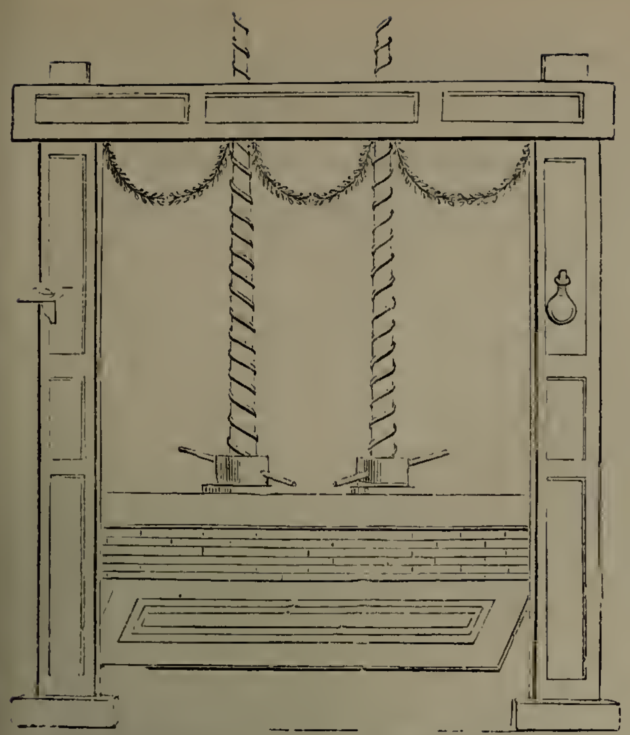
452.—Merino or Short-wool Fleece, for Woollens.

453.—Teazle, used for "raising" Cloth.



448.—Wool-carding Machine.

450.—The Jersey-wheel, formerly used for spinning Cotton and Wool.

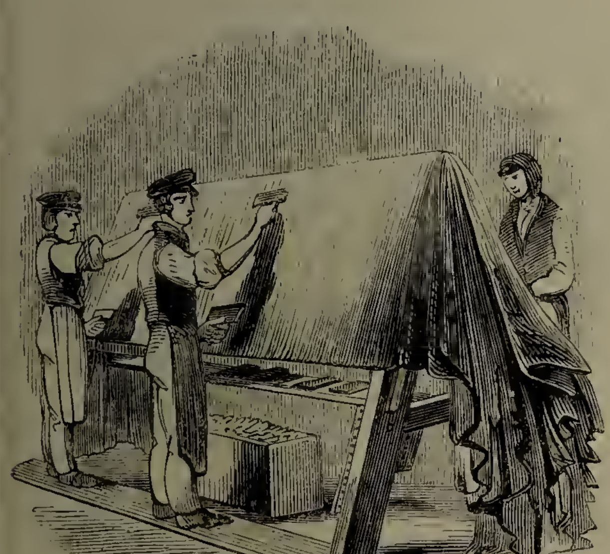


459.—Roman Clothes-press. (From a Painting at Pompeii.)

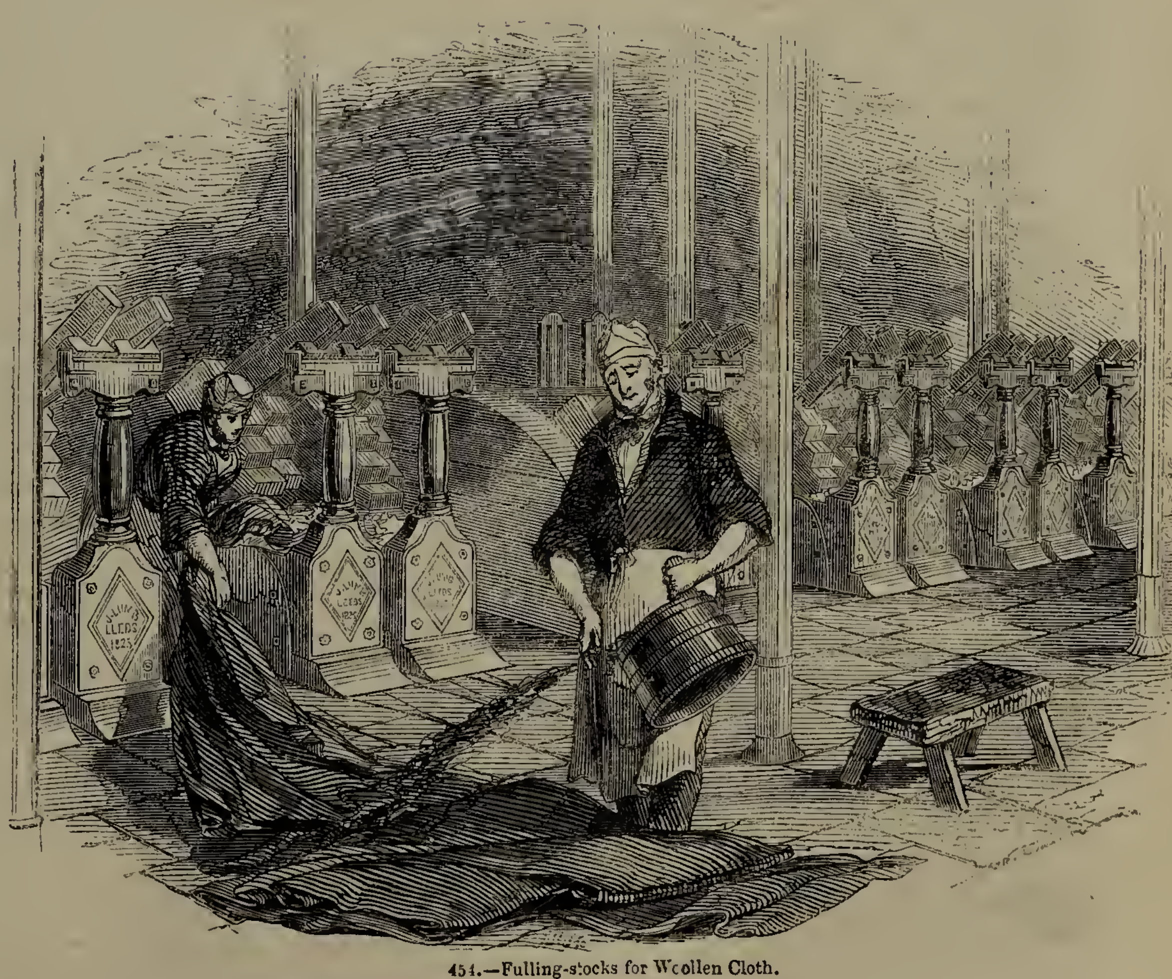
457.—Woollen-cloth Fullers and Scourers. (From a Painting at Pompeii.)

455.—Cutting and fixing Teazels, for "raising" Woollen Cloth.

458.—Woollen-cloth Cleaners. (From a Painting at Pompeii.)



456.—" Hand-raising" Woollen Cloth.



454.—Fulling-stocks for Woollen Cloth.

of spiral turns in a given space; and therefore, by governing the relative velocity of the two movements the superintendent can give any required closeness to the twist.

The *doubling*, as we have stated, consists in combining two or more threads together, and twisting them around each other. It is effected sometimes by a machine of rather complex arrangement, and at other times by a sort of hand-wheel (Fig. 438). In the latter method, there are fixed up near a hand-wheel as many bobbins as there are to be threads doubled together. The ends of all the threads are taken up between the fingers of the doubler, passsed through a sort of loop, and attached to the wheel. Then, by turning the wheel with the right hand, all the threads become doubled, or laid side by side.

The threads so doubled, in order to have coherent strength given to them, require to be "twisted," or "thrown" around each other, an operation very similar in principle to that of the previous twisting. The doubled threads are wound on a sort of open framework, or long horizontal reel (Fig. 439), and the ends of the various threads, after being carried through eyes or guide-pins, are attached to the rotating flyers or loops. The action, then, is the same as before: the silk, in the act of exchanging a horizontal rotation for a vertical one, becomes twisted, all the component threads being coiled round each other. The direction of this twist has something to do with the purpose to which the thread is to be applied. In the making of "tram," the silk is not twisted immediately after being wound, but the raw silks are doubled, and then twisted to the right hand; for "organzine," the raw silk is wound, then twisted to the left, then doubled, and the doubled thread finally twisted to the right.

Sometimes silk is twisted in nearly the same manner as ropes are made, that is, in a long alley or gallery, with a wheel at one end of it. This occurs when the silk is required to be made very dense, thick, and strongly twisted. On one face of the wheel (Fig. 441) are ten or twelve hooks ranged near the circumference. Threads of silk are fastened at one end to these hooks, and at the other to a set of hooks fixed in a frame resting on the ground. A handle sets in rapid revolution all the hooks attached to the wheel; and this movement causes the several threads to twist very closely, each one around its own axis. Boys run to and fro to attach and detach the threads.

It is by such a series of processes, comprising chiefly winding, doubling, and throwing, that the silken filaments are brought into a fit state for dyeing, or for weaving, or wearing.

As to *silk-spinning*, this is a very different branch of manufacture. It is applied to "floss-silk," to the silk of defective cocoons, and to the waste silk produced in any of the processes. If the silk cannot, for any reason, be worked out into an extended and unbroken thread, it is destined for the silk-spinning mills, where it is treated almost exactly in the same way as cotton, being carded, drawn, roved, and spun. It is an inferior kind of material, and is used in making cheap silk shawls and handkerchiefs, intended to look well, and yet to be sold cheap. Fig. 442 shows a vertical sketch of one of the complicated pieces of apparatus now employed in this department of the silk manufacture.

As in the case of cotton, we shall postpone the consideration of the arts relating to the dyeing and weaving of silk, till we can take up all the four great classes of fibrous materials together. Let us, then, at once proceed to

WOOL: WOOLLEN AND WORSTED MANUFACTURES.

Here, unlike the two former instances, we have in our own country the raw material on which the skill of the manufacturer is exercised. The sheep of Leicestershire and other districts yield wool fitted for many branches of the manufacture. But it has been found, nevertheless, that the well-being of the manufacture, as a whole, depends on the privilege of choosing wool from any and every country. There was a time when legislative attempts were made, in various ways, to compel the use of English wool for all purposes, without regard to its relative unfitness for some of them; but matters are now better understood; and our manufacturers purchase English wool, or German wool at Leipsic, or Cashmere wool or Alpaca wool from Asia, or Australian wool from the colonies, just as they may deem best.

All the productions from wool are divisible into two great classes: those in which *short wool* is employed, and which come under the denomination of *woollens*; and those in which *long wool* is used, known as *stuffs* or *worsteds*. It is true that this subdivision is not strictly exact in all instances, but it is sufficiently so for our object. Generally speaking, *broad cloth* may be taken as a type or exemplification of woollens, and *stuff* of worsteds; but the varieties are very great. Thus—*blankets, flannels, stuffs, merinos, mousseline de laines, shaloons, says, moreens, calimancoes, camlets, lastings, baize*, and many others, are examples of long-wool manufacture, modified in various ways; *broad cloths* are examples of plain weaving, and *kerseymere* of twilled weaving, in the short-wool manufacture; *serges* are twills, having worsted warp and coarse woollen weft; *bombazeens* are a twilled mixture of worsted and silk; *poplins* are an untwilled mixture, showing more silk at the face and more worsted at the back; the modern cloths, called *Saxonies* and *Orleans*, are made of unfulled woollen, sometimes mixed with cotton; *stuffs* are made wholly of worsted; *merinos* are a fine woollen twill, sometimes printed; *Cashmeres*, if real (which is seldom the case), are made from the hair of the Tibet goat, but are generally made of sheep's wool; *challis* have a silk warp and a woollen weft, and are generally printed; *mousseline de laine* was originally (as its name, "wool muslin," implies) all wool, but very frequently contains cotton; *Norwich crape* is formed of wool and silk, *Crêpe de Lyon* of worsted and silk. It would be impossible to enumerate all the varieties which modern art has introduced in the admixture of woollen, worsted, silk and cotton, in the same piece of goods; but the above will serve as examples. The two distinctions, however, in respect to wool, will be sufficiently kept in mind by designating them *clothing wool* and *hosiery wool*, since hosiery was the primary purpose to which long wool or worsted was applied.

Wool Manufactures of Asia.

Before we notice the routine of industry in these branches, it may be well to say a word or two respecting the kind of goods manufactured in the East, because many of these are made of goats' hair rather than of sheep's wool. From a very early time, as we had occasion to observe in a former page, the manufacture of woollen goods has been known and carried on by many nations among the Asiatics. Some of the breeds of sheep are very remarkable; but it is principally to the hair of goats that the celebrity of the Eastern manufacture in these matters has been due. Many of the wilder animals, such as the beaver, the racoon, the wild cat, and the otter, produce both hair and wool, the hair forming the long and conspicuous outer fibres, and the shorter fibres of wool lying hidden beneath them. It is, as we shall presently see, in the different power of the different kinds of wool or hair to become *felted* or matted together, that the manufacture takes its peculiar cast. One or two examples of the kind of hair-wool manufactures of Asia will sufficiently illustrate this part of the subject.

The persons who, in our own country and at the present day, purchase worsted or woollen goods under the denomination of *Cashmeres*, are or ought to be aware that such goods are Cashmerian only in name. A real Cashmere shawl, made by the inhabitants of that Indian valley from the wool of a peculiar variety of goat reared on the plains of Tibet, is a most costly article, eagerly sought after by the rajahs and sultans of the East, but finding its way to Europe very rarely indeed. To make a pair of large and handsome Cashmere shawls requires the labour of twelve or fourteen men for half a year. The late Runjeet Singh, the chief of Lahore, gave five thousand rupees for a pair of these woollen shawls, the patterns of which represented his victories. The animals from which the material is obtained (Fig. 443) are covered by nature with two kinds of coat or clothing; the one fine, curly, generally grey, and imparting to the skin a down more or less thick, as if to guard it against cold and damp: the other coarse, lank, and giving a general colour to the animal; and as it is only the inner and finer coating which is used for the fine shawls, the quantity produced is very limited and therefore high priced. The down, called *poshm*, is collected from flocks of goats on the plains of Tibet, and brought to the confines of Cashmere on the backs of sheep; it is then cleaned, and one fourth of it (being all that is fitted for the shawls) is carried on men's backs the remainder of the distance to Cashmere. When arrived at Cashmere, it passes into the hands of the merchants, who sell it in small quantities to the weavers at the rate of about two rupees per pound. The thread is dyed a great variety of colours, then stiffened with rice-water. Various articles are woven with these coloured threads, the process being slow and tedious on account of the rude construction of the looms. Shawls, coverlets, handkerchiefs, turban-pieces, gloves, socks, and other garments are woven of this *poshm*. The shawls are washed after being woven to remove the rice-stiffening, and a fine pale yellow colour is imparted by means of sulphur-fumes.

The trade in shawls at Cashmere is rather a curious one. M. Vigne, in his 'Travels in Cashmere,' thus describes it:—"The *mokym*, or broker, who transacts business between the shawl manufacturer and the merchant, is a person of great importance in the city; and the manner in which their transactions are carried on is singular. They have correspondents in most of the larger cities of Hindustan, whose business it is to collect and forward every species of information connected with their trade. By their means they seldom fail to hear of any *sandagur*, or merchant, who is about to start for Kashmir;* even from such a distance as Calcutta; and, if he be a rich man, the mokym will send as far as Delhi to meet him, and invite him to become his guest during his sojourn in the valley. Perhaps again, when the merchant, half dead with fatigue and cold, stands at length on the snowy summit of the Pir Panjal, or either of the other mountain passes, he is suddenly amazed by finding there a servant of the broker, who has kindled a fire ready for his reception, hands him a hot cup of tea, and a kabab, a delicious kalioun, and a note containing a fresh and still more pressing invitation from his master. Such well-timed civility is irresistible; his heart and his boots thaw together, and he at once accepts the hospitality of the mokym, who, it may be, is awaiting the traveller, with a friendly hug, at the bottom of the pass, two or three days' journey from the city, to which he obsequiously conducts him. He finds himself at home at the house of his new friend, and himself and servants studiously provided with all he can require. His host, of course, takes care to repay himself in the end. He has an understanding with the shawl manufacturers who frequent his house, so that the guest is at the mercy of both parties; and should he quarrel with the broker, and hope to make a purchase without his intervention, he would find it impossible. No shawl-vender can by any possibility be induced to display his stores until the approach of evening, being well aware of the superior brilliancy imparted to their tints by the slanting rays of the setting sun; and when the young sandagur has purchased initiation by experience, he will observe that the shawl is never exhibited by one person only; that the broker, perhaps, apparently inattentive, is usually sitting by, and that under pretence of bringing the different beauties of the shawl under his more especial notice, a constant and freemasonic fire of sneezes and pinches, having reference to the price to be asked, and graduated from one hundred to a five rupee power, is secretly kept up between the venders by means of their hands extended under the shawl. When the merchant has completed his purchase, the mokym, who was before so eager to obtain him as a guest, pays him the compliment of seeing him safe to the outside of the city, where he takes leave of him at Chartubal, the very last place within it."

Other districts of Asia in like manner produce flocks of goats or of sheep, which have given rise to manufactures among the neighbouring inhabitants. One other example will suffice here to illustrate this matter.

A paper was read before the Asiatic Society a few years ago, from Lieutenant Conolly, on the manufacture of woollens from the wool of the Angora goat of Asia Minor, in which some of the details are curious. The natives call this goats' hair by the name of *tiftik*, while sheep's wool is called *yapak*. When the *tiftik* fleeces have been shorn, the women separate the clean from the dirty, pass it through fine-teethed iron combs, and spin it into thread; while spinning they moisten the hair with spittle, which they prefer in the melon-season, as the saliva becomes more mucilaginous when this fruit has been eaten. "Before this yarn is used by the weaver," says Lieutenant Conolly, "it is well saturated with a glutinous liquor called *chirish*. This is made from a root like a radish, which comes to Angora from the neighbourhood of Conia. It is dried and pounded, mixed with dates, and well shaken in a bag; then the liquor is strained off, and small skeins are steeped in it; while large hanks are watered by the mouth when they have been spread out, according to the following process, which I may describe as witnessed by us at Angora:—We found the workmen before sunrise on a level space by the banks of the Angora stream. Upon a centre and two end cross-trees was rather loosely stretched a double web of yarn, seventy feet by seven, which was kept extended and separate by sliding cross-sticks. Two men walked up and down the sides of this frame at the same time, nearly opposite to each other, holding bowls of chirish liquor, made into a thin yellow mucilage; of this they continually squirted, or rather blew out mouthfuls in alternate showers, all over the web; while others followed them, to press the threads together for a moment, and then to change their position relative to each other, by means of the sliding cross-bars mentioned, so that all might be equally moistened, as well as to rebind any threads that had given from the tension. The chirish liquor had a sweetish and not unpleasant taste, but the squirters complained that it totally destroyed their teeth, and showed bare gums in proof. They distributed their jets with singular dexterity, in broadcasts of the minutest drops; and expressed doubts whether, considering the clammy nature of the liquor used, any watering-pot could be made to do their work as well, and save them from its inconvenient effects. This operation is repeated several times: the work is always commenced in the cool of the morning, so that it may be completed ere the heat of the sun can operate to dry the thread quickly. . . . The women of Angora knit gloves and socks with the *tiftik* yarn, making them both furry and plain, and making some socks of the better sort so fine as to cost one hundred piastres the pair. The surplus of their yarn they sell to native weavers of stuffs. The weaver seeks threads of equal thickness, and takes the skeins that he matches back to the women spinners, who reel them into one thread, assisting their operations with *chirish* mucilage. The connected thread being returned to the weaver in hanks,

* Writers on Indian subjects are by no means particular in the mode of spelling Indian names. The district now under notice is designated in no less than ten different ways, by different writers—Cashmere, Cashmeer, Cashmire, Cashmir, Cachemere, Cachemire, Kashmere, Kashmeer, Kashmire, and Kashmir.

he, with a hand-wheel, winds off small portions through a pan of water on to bits of reed cut to fit his shuttle."

The Processes of Preparing and Spinning Wool.

Returning to our own country, we may now watch the processes incident to the manufacture of woollens, illustrative of the peculiar differences in texture between cotton and wool.

Each "fleece" of wool (being the wool from one sheep) weighs somewhere between two pounds and eight pounds, according to the quality; the fine short wool for woollens being much smaller in the fleece than the long coarse wool for worsteds. The foreign fleeces, from which our best broadcloths are chiefly made, are tied up into bundles of three or four each; and several of these bundles are made up into packs. On opening one of the packs, the wool is found to be matted and clotted together, requiring to be loosened before the manufacture can commence. In the act of opening or separation by the fingers, the workman sorts all the locks of wool into different parcels, according to its fitness for different purposes. Some of the packs contain bundles of different qualities; some of the bundles contain fleeces of different qualities; while every fleece contains wool of different qualities in different parts. Hence the examination to which it is subjected is very minute; especially as the sorting is determined not only by difference of fineness, but also according to the softness, strength, colour, cleanness, and regularity of the fibres which form the wool. An experienced workman will sometimes carry the subdivision so far as twelve or fifteen qualities; and such is the delicacy of touch required for this office, that if the workman ceases thus to occupy himself for any considerable period, his fingers lose the necessary tact.

When the locks of wool have been opened and sorted, and the dirt and dust allowed to separate from them, they are washed in a hot liquor calculated to remove the grease which the wool had imbibed from the sheep. This done, the disentanglement of the fibres is effected by a machine, exactly the same in principle as the "willow" employed in the cotton manufacture. It is called sometimes a "willy," sometimes a "devil," but always consists of a revolving machine, containing spikes which tear asunder the locks of wool, leaving the fibres more or less disentangled. Some kinds of wool require to be willowed more than once, to effect the disentanglement; while all of it needs a little lubrication with oil, to soften and render it more workable.

The next stage is to lay these fibres in a parallel and even direction, preparatory to the spinning operation. The principle involved bears a close resemblance to that of the preparation of cotton; since, in the one case as well as in other, there are fine fibres lying crosswise in a confused manner, and requiring to be brought all into one direction, equable and regular: the difference of the fibrous structure leads to variations in detail which will be noticed as they occur. There are three machines involved in this preparation of wool—the "scribbling-machine," the "carding-machine," and the "slubbing-machine." In that variety of the wool-manufacture which relates rather to worsted or long-wool than to clothing-wool, the fibres are brought out straight by a kind of *combing*, in which machines, of which two forms are shown in Figs. 444, 445, are employed. This matter, however, will come on for notice a little farther on. We may here briefly explain, that of the three preparing machines necessary for clothing-wool, the "scribbling-machine" consists of a system of cylinders, on the surface of which are numerous points or teeth, bent in particular directions, and acting near each other. A girl takes the oiled wool by handfuls, and lays it on a kind of apron or cloth attached to the machine. This apron moves onwards, and the wool is caught by the teeth of the first cylinder, carried round, caught a second time by another set of teeth, carried round still further, and so on; being disentangled and opened by every transference from one cylinder to another; until at length it leaves the machine in the form of a light flocculent layer, all the fibres being disentangled, but no approach being yet made towards the parallel arrangement of the fibres.

The "carding-machine," or card-engine (Fig. 448), like the similarly-named piece of apparatus employed in the cotton manufacture, completes the work of the scribbling-machines, by giving to the fibres of wool a parallel and uniform arrangement, and also rolls them up into a pipe or cylinder. An attendant in the first place weighs the wool accurately, according to the quantity required for any particular stoutness of cloth, and lays it on the feeding-aprons of the machine, from whence it is drawn in to be acted on by teeth, as in the former case. The teeth comb it out to a regular form, and at the same time fashion the mass of fibres into detached flat layers or bands, each measuring about thirty inches long by six wide. Each of these delicate bands is, by a remarkable adaptation of the machine, rolled up into a rod or solid pipe thirty inches long, with a thickness varying from a quarter to half an inch. This roll is very curiously formed; for an inspection of its structure shows that the fibres do not run *lengthwise* of the piece, but across; so that the roll may almost be considered as a succession of rings. Such an arrangement would be utterly inconsistent with the requirements of the cotton manufacture; but in the case of wool, the peculiar property of *felting* (to which we shall presently have occasion to allude more particularly) is brought more fully into action by it.

These rolls of wool are called "cardings;" and the operation of the next piece of machinery, the *slubbing-machine*, or the *slubbing-billy*, is to connect all these cardings into a continued roll called a "slubbing." The reader has probably by this time had many inducements to smile at the odd designations which workmen are wont to give to the machines employed by them—the "jenny," the "billy," the "mule," the "devil;" "scribbling," "throstling," "throwing," "slubbing,"—all are examples of nomenclature which it would be somewhat difficult to account for. The slubbing-billy takes part in a curious train of operations. There is at one end of the machine (Fig. 449) a sloping board, on which the rolls or cardings of wool are laid side by side, by young boys called "pieceners." By the action of the machine these cardings are caught up, drawn in, and so elongated by a kind of spinning-process, as to be reduced in thickness to a cord about one-twelfth of an inch in diameter. Each carding, originally about a yard long, becomes elongated to several yards; but it would still be a piece of only determinate length, were not arrangements made to add carding to carding as the operation proceeds. It is the office of the "pieceners," therefore, to place new "cardings" on the sloping board before the whole of those previously applied have been drawn in, and to squeeze the ends of the one set to those of the other, sufficiently to enable them to cohere. The result of this is that a continuous cord or loose string is formed, as long as the pieceners keep up a supply of new cardings. At the right hand side of the machine is seen a wheeled carriage or frame, something like that employed in the "spinning-mule," and having a row of spindles upon it. By the management of a handle turned by a workman, and by moving the carriage to and fro, the "cardings" are stretched into "slubbings," and those slubbings are wound in the spindle.

Here, then, we have brought the wool to the state of a loose cord, an ounce of the material forming from one to two hundred yards of the cord, according to its thickness. This is analogous to the "rovings" of the cotton manufacture, and is next spun into yarn by machinery and processes bearing so near a resemblance to those before described as to render particular description unnecessary. For instance, where the manufacture is still conducted by hand, as it used wholly to be, the wool is carded by hand-cards, such as are shown in the lower part of Fig. 450, and spun by some such a wheel as that depicted in the upper part of the same cut; while in the factory method the wool is often spun into yarn by means of a "mule" spinning-machine (Fig. 451) very similar in construction to that employed in the cotton-manufactories.

When the woollen yarn is spun, it is handed over to the weavers, whose labours will shortly come under our notice; and, when woven, the woollen cloth goes through a train of finishing processes, to which a little attention may now be paid. It may be well to state here, in reference to the *colour* of the wool, that certain differences are observable between cotton and wool in respect to dyeing. Cotton goods are never dyed while yet in the state of loose unspun wool; they always receive the colours artificially imparted to them, either when in the state of yarn before weaving, or after being woven. In the case of wool, however, the material is not dyed in the state of yarn: it is dyed either in the raw state, before spinning, or in the finished state after weaving. This difference gives rise to the two designations of "wool-dyed" cloth and "piece-dyed" cloth, according to the period in the operations when the dyeing is effected. With this difference, the processes subsequent to weaving are pretty much alike in both cases.

To understand the reasons for many of the processes connected with the woollen-cloth manufacture, it will be necessary to glance at

The Felting Properties of Wool.

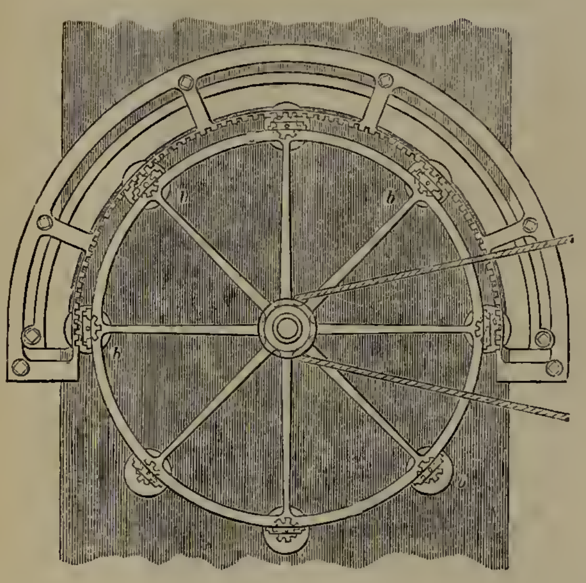
Before the felting process is commenced, the oil employed in the earlier stages of the manufacture, to assist the working of the wool, requires to be removed; and this removal is effected by a kind of scouring, the cloth being moistened with soap and water, and beaten with wooden mallets in a kind of trough. Next ensues the *fulling*, *felting*, or *milling*, that process which illustrates more than any other the remarkable qualities of wool. The fact itself, and the various attempts at explaining it, are almost equally curious. When woollen fibres, especially those of the *short*-wool fleeces, are beaten, pressed, or rubbed together, they cling so intimately one to another as to form a tolerably firm layer or group. Such is the case in forming the "nap" of woollen cloth, in forming the body as well as the covering of a beaver hat, and in various other instances. There is an odd legend current respecting the origin of felting, to the following effect:—St. Clement, fourth bishop of Rome, being obliged to fly from persecution, found his feet to be so blistered by long-continued travel, that he was induced to put a little wool between his sandals and the soles of his feet. On continuing his journey, the warmth, moisture, motion, and pressure of the feet, caused the wool to clot and mat together into a coherent mass; and this fact led him to think that such felted wool might be a useful material for manufacturers. But unfortunately for the credit of this legend, the felting of wool has been known from very early ages by the nomadic tribes of central Asia, who employ the wool of their sheep for tents and clothing.

In modern times, when the "reasons for things" are more sedulously inquired into, the cause of the felting property has engaged a good deal of attention. Dr. Young suggested that "the reason of the contraction of the cloth in felting is probably this, that all the fibres are bent by the operation of the fulling-hammers, but not equally; and those that have been the most bent are prevented, by their adhesion to the neighbouring fibres, from returning to their original length." A more correct mode of judging arose from the observation of the fact, that if a few filaments of wool be drawn between the finger and thumb, in a direction from the root to the tip, the surface of the fibres seems smooth and regular; but, if the direction be reversed, there appears to be some slight roughness or interruption to the movement. Mr. Bakewell offered a suggestion that this roughness may be a kind of tremulous motion, "caused by minute vibration, more easily excited in one direction than another, owing to the peculiar arrangement of the particles." It was not, however, till the microscope was applied to the examination of the fibres, that the true cause of felting was discovered. Dr. Ure, who has devoted a good deal of attention to this mode of examination, and who recommends that the fibres should be immersed in Canada-balsam while under examination, says:—"The filaments of wool so seen in a powerful achromatic microscope have somewhat of the appearance of a snake, with the edges of its scales turned out a little from the surface, so as to make the profile line of the sides look like a fine saw, with the teeth sloping in the direction from the roots to the points. Each fibre of wool seems to consist of serrated rings imbricated over each other, like the joints of equisetum. The teeth differ in size and prominence in different wools, as well as the annular spaces between them—the latter being in general from $\frac{1}{2000}$ to $\frac{1}{3000}$ of an inch, while the diameter of the filament itself may vary from $\frac{1}{1000}$ to $\frac{1}{1400}$. The transverse lines resemble a little the wrinkles of an earth-worm, but they are less regular in their course. Were a number of thimbles with uneven edges to be inserted in each other, a cylinder would result, not dissimilar in outline from a filament of Spanish Merino wool—the fleece in which this texture is best developed. In the finest Saxony wool, the articulated appearance is also prominent, and of course the serrated profile of the edges. They are likewise well-marked in Mr. M'Arthur's best long combing-wool. In the Leicestershire long staple the serrations are very minute, and the cross-markings indistinct." In Figs. 446, 447, several varieties of wool-fibre are shown, as seen in a powerful microscope, and exhibiting different degrees of the tooth-like serrations at the surface. It is observable that the long wool used for worsted is less decidedly marked than that fitted for woollen cloth. The fleece of the Merino sheep (Fig. 452) has fibres well fitted for this latter object; and it is for this reason that sheep of this breed, whether from Spain or from Saxony, are so much valued for this department of industry.

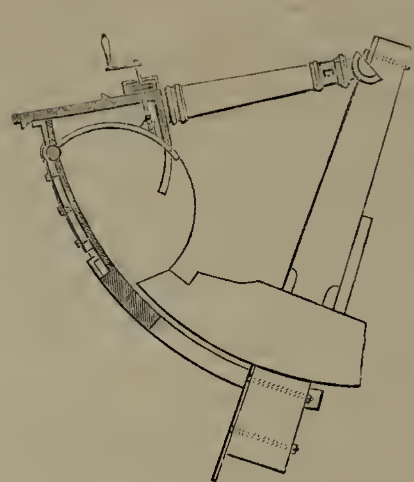
It is, then, owing to minute projections on the surface of the fibres, that wool acquires the property of felting; and we may now see how the operation is performed in the manufacture. The "fulling-stocks" employed are hollow machines, in which a ponderous oaken hammer or "stock" vibrates up and down, giving forcible blows to anything that may be in the machine. In the background of Fig. 454 are seen many of these "fulling-stocks;" while Fig. 460 shows a sectional representation of one of them. The woven cloth is partially opened and sprinkled with liquid soap from a vessel held in the hand (Fig. 454). It is folded up into a pile, placed in the machine, and there beaten by the hammers. The finest cloth is beaten for nearly two or even three entire days; being taken out four or five times, to have a renewed supply of liquid soap. During this long-continued action, the fibres, being at every blow strongly impelled together, and driven into the closest possible contact, hook into each other by the serrations at their surfaces, until they become inextricably entangled: the fine fibres of one thread of yarn lock into those of another, and the result is, that the distinction between warp and weft becomes hardly perceptible. In the modern woollen factories the fulling-stocks are worked by a steam-engine; but at an earlier period of the manufacture water-wheels were employed for this purpose. The rivers flowing through many of the valleys in the West Riding of Yorkshire used to turn many a water-wheel so appropriated. Dyer, in his poem of 'The Fleece,' thus alludes to the industrial features of the district in his time:—

464.—Coloured-cloth Hall at Leeds: present time.

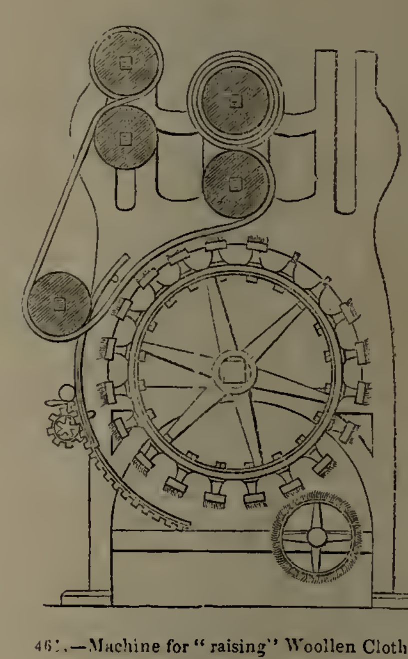
466.—Saxony Spinning-wheel.



462.—Cloth-shearing Machine.

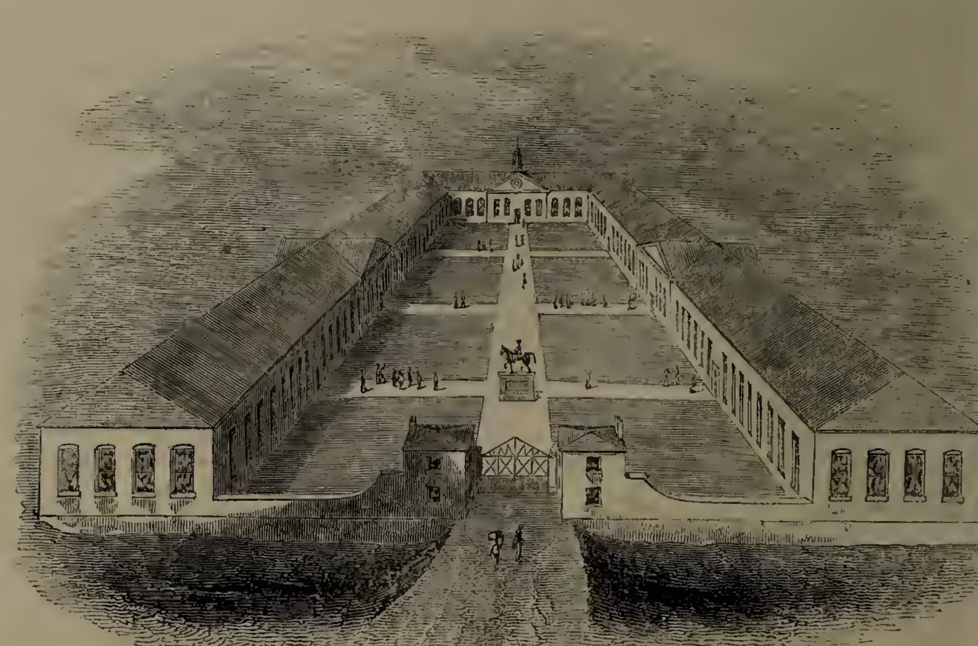


460.—Fulling-machine.

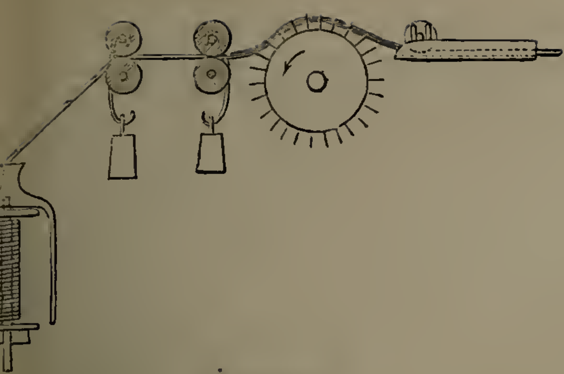


461.—Machine for "raising" Woollen Cloth.

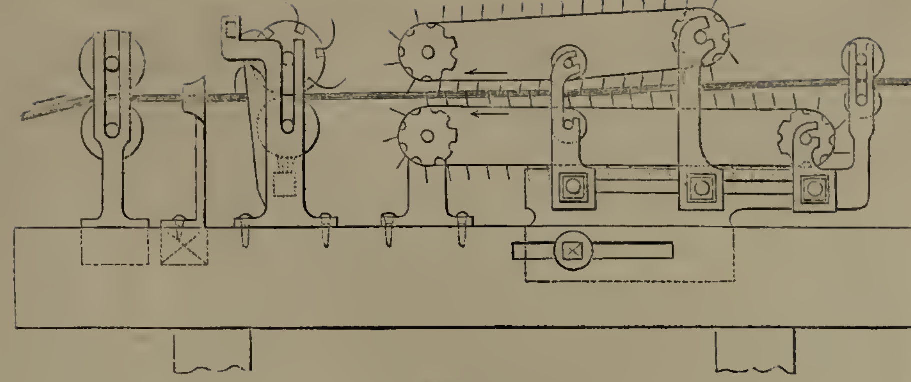
465.—Spinning-wheel.



463.—The former Cloth-market, Leeds.



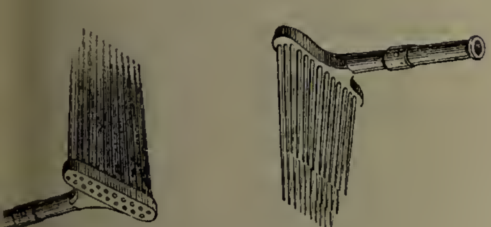
471.—Worsted-roving.



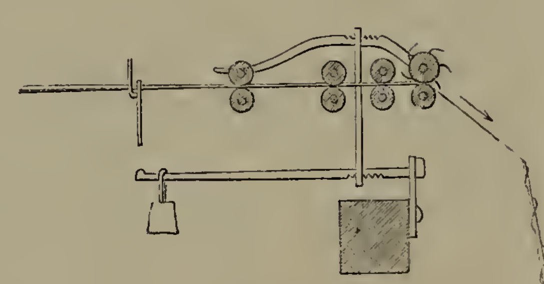
474.—Worsted-spinning.

469.—Wheel for combing Worsted.

467.—Long-woolled or Leicestershire Fleece, for Worsted.

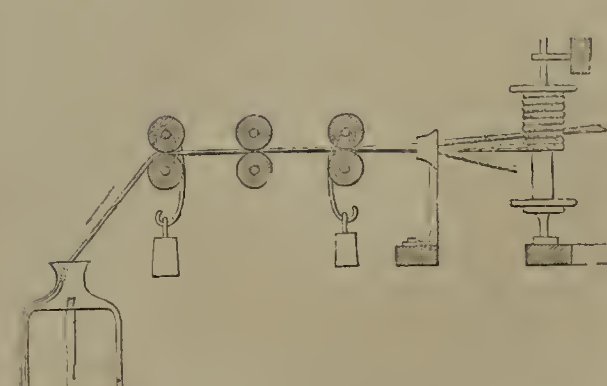


468.—Hand-combs for long wool.



472.—Worsted Throstle.

470.—Drawing Worsted into Slivers.



473.—Worsted-spinning.

"Next from the slacken'd beam the woof unroll'd,
Near some clear sliding river, Aire or Stroud,
Is by the noisy fulling mill receiv'd;
Where tumbling waters turn enormous wheels,
And hammers, rising and descending, learn
To imitate the industry of man.
Oft the wet web is steep'd, and often raised,
Fast dripping, to the river's grassy bank;
And sinewy arms of men with full-strain'd strength
Wring out the latent water."

Dressing and Finishing of Woollen Cloth

Such, then, is the nature of the processes depending more or less on the felting property of wool. When the cloth has by these means been properly felted or "fulled," it is stretched out and hung up to dry. We have here an illustration of the changes which the manufacture has undergone within the last few years. Some time back every woollen-cloth manufactory had a "tenter-field" (or else there was a tenter-field used by several manufacturers in common): this was a large open space of ground, containing rows of poles and rails studded with tenter-hooks, on which the cloth was stretched while drying. Formerly, in Halifax and other towns, there used to be seen many "tenter-fields," with the cloth hanging up in them to dry: but this method is fast giving way to the custom of drying the cloth in steam-heated rooms; and some of the manufacturers have turned their tenter-fields into gardens for their workpeople—a pleasant memento of improvement in a twofold point of view.

The cloth becomes greatly thickened by the process of fulling; while its length and breadth are diminished nearly one-half. Its surface is rough and unseemly, and has to undergo a remarkable process before completion. It is first "raised;" that is, the mass of the cloth is raked up by a brush, made either of wires or of teazle-heads, and used either by hand or by machine. The use of the teazle (Fig. 453) for this purpose is somewhat remarkable, since it has never yet been wholly superseded by mechanical arrangements. The teazle (*dipsacus fullonum*) is a plant cultivated by country people in Wilts, Essex, Gloucester, Somerset, and one or two other counties. The heads are in a fit state for cutting about July or August; and, when cut, they are fastened to poles to dry them. This drying of the teazle-heads is a very troublesome process; and the whole details of the cultivation are rather precarious. When dry they are picked and sorted into bundles for sale, from nine to ten thousand forming a "pack." As there is no other plant to replace this when scarce, the price of the teazle varies greatly according to the scarcity of the season. From four guineas to twenty-two guineas per pack are paid, according to circumstances; but the average is stated to be from about five to seven guineas. When the trade price exceeds about eight guineas the pack, it is worth while to import from Holland, where the cultivation is also carried on. When the teazles come into the hands of the woollen-manufacturers they are fixed into frames or handles adapted to the purpose in view. A boy (Fig. 455) cuts off part of the stalks with a pair of scissors; and a man then fixes the teazles into oblong iron frames, which frames are afterwards fitted to the surfaces of cylinders.

The object of using these teazles is to draw out the ends of the wool from the woven cloth, so as to bring a pile or nap upon the surface, free from twistings and knots, and also to comb off the loose fibres of wool. The teazle is enabled to effect this, because the head is composed of incorporated flowers, separated by a long rigid filament, the terminating point of which is furnished with a fine hook. These hooks comb out and loosen the woolly fibres; and the peculiarity of the service which they render is this; that if any of the hooks encounter a knot or a resistance in the cloth, they will break without injuring the cloth itself. This is the great point in which teazles have been found preferable to any arrangements of wire-teeth; since the latter tear the cloth rather than give way to obstructions by breaking. But there are great inducements to the invention of some substitute, for the use of the teazles is rather costly. One piece of cloth will require from fifteen hundred to two thousand teazles in the process of "raising." In carrying on this process by hand the cloth is extended over a sloping frame or stand (Fig. 456), and the men stand on either side, rubbing the cloth with hand-cards, supplied either with teazle-heads or with wire-teeth. In the machine-method the teazles or teeth are affixed to the surface of cylinders, and the cloth passed along in contact with them (Fig. 461).

When the loose and delicate filaments of wool have been thus worked up to a rough state, the whole of them are cut or sheared to a surface beautifully level and even, by a process which has undergone many modifications, but which is remarkable in every form. In former times this was effected wholly by hand-shears. The cloth was stretched out over a stuffed table, and the workmen proceeded to clip the points of the fibres from end to end, and from side to side, by laying the shears flat down on the cloth and making cuts with them in regular succession. This was an operation requiring very great care and skill, and the workmen employed at it earned high wages. At a later period an improvement was effected, whereby the shears were worked by machinery instead of by hand labour. Subsequently other machines were invented to bring about the result in various ways, but all acting on a principle partaking somewhat of that of shears or scissors. One of the modern cloth-shearing machines (Fig. 462) has a series of disk-formed cutters, *b b b*, working against a thin bar of steel, of a semicircular form; the cutters, in their revolution, travelling round against the edge of the bar or blade in such a way as to shave off the filaments standing up on the surface of the cloth. The wheel, set in motion by machinery, imparts motion to the circular cutters attached to it through the medium of a kind of rack. The most general machine now employed, however, consists of a long spiral cutter acting against a straight blade, and the cloth being drawn between them.

The finer kinds of cloth are raised and sheared two or three times, until the nap has acquired a beautiful degree of smoothness and regularity. Many minor processes are also about this time employed, especially for the better qualities of cloth. For instance: the cloth is "boiled," to impart to it a certain lustre; it is "burled," or "picked," to remove knots and imperfections; it is "inked" (if black or blue cloth) by women, who carefully examine the cloth in every part, and put a spot of ink on any white or light-coloured fibres that may present themselves: it is "pressed" between hot iron plates and smooth mill-boards; it is "steamed," and then brushed by passing the cloth over cylinders covered either with brushes or a kind of plush. The coarser varieties of cloth do not require so many finishing processes.

Before quitting that part of our subject relating to the finishing of woollen cloth, it may be well to notice a method which the Romans adopted in scouring or cleaning their woollen goods. It was mentioned in an earlier part of the present chapter that the preparation of such cloth formed part of the industrial arts of the Romans; and there are some paintings at Pompeii which throw a little light on the arrangements connected with this subject. In the volumes relating to 'Pompeii' it is said that the art of fulling and scouring cloth, owing to the difference between ancient and modern habits, "was of much greater importance formerly than it now is. Wool was almost the only material used for dresses in the earlier times of Rome; silk being unknown till a late period, and linen garments being very little used. Woollen dresses, however, especially in the hot climate of Italy, must often have required a thorough purification; and on the manner in which this was done of course their beauty very much depended: and since the toga, the chief article of Roman costume, was woven in one piece, and was of course expensive, to make it look and wear as well as possible was very necessary to persons of small fortune. The method pursued has been described by Pliny and others; and is well illustrated in some paintings found upon the walls of a building, which evidently was a *fullonica*, or scouring-house."

Fig. 457 is a copy from one of the paintings here alluded to; and from the description given it appears that the process of scouring commenced by washing the cloth in water containing fuller's earth or some other kind of detergent clay. This was done in vats, where the cloth was trodden and well worked by the feet of the fullers. In the painting there are four persons represented thus employed; the dress, consisting of two tunics, being tucked up so as to leave the legs bare. Three of the men seem to have finished their work, and to be wringing out the cloth; while the other, his hands resting on the wall on each side, is jumping and stamping on the cloth in the vat. When dry, the cloth was brushed and carded to raise the nap, at first with metal cards, and afterwards with thistles. The cloth was then fumigated with sulphur, and bleached in the sun by throwing water repeatedly on it, while spread out on gratings. In another of the paintings (Fig. 458) a workman is represented as brushing or carding a tunic suspended over a rope. Another man carries a frame and pot, intended probably for fumigation and bleaching: the pot probably contained living coals and sulphur, and was placed under or within the frame; while the cloth was spread over the exterior of the frame, so as to be fully exposed to the action of the vapour rising from the burning materials. On the left is a female examining the work which a younger girl has done upon a piece of yellow cloth. A golden net upon her head, a necklace and bracelets, denote a person of some consequence; and she is supposed to have been either the mistress of the establishment or a customer come to examine some work executed for her.

Another of the pictures at the *fullonica* represented a clothes-press (Fig. 459) very much resembling presses still in use. This was probably intended to press and smooth the cloth after it had been scoured and bleached.

Returning now to our own country, a glance may be taken at the

Commercial Arrangements of the Woollen Manufacture.

These arrangements are in many respects curious; since the mode of sale depends a good deal on the mode of manufacture. In earlier times, before the introduction of machinery, the different members of a family used to assist each other in the operations connected with the manufacture; but by degrees there have become observable three different systems of carrying on the manufacture; which we may term, respectively, the "master-clothier" system, the "cottage-clothier" system, and the "factory" system. According to the first, which prevails principally in the West of England, the master-clothier is a capitalist, who buys his own wool, and then gives it out to be worked up into cloth by persons living near or around him: one set of men being employed to comb and card the wool—another to make it into "slubbing," and to spin; another to weave, another to "scour," to "mill," to "raise," to "shear," and so on; and each man bringing home his work when done, and receiving payment for it from the master-clothier. The last of the three, the "factory" system, is that in which the capitalist or master-clothier takes matters more completely under his own superintendence. He has a large building, containing rooms and machines for the accommodation of a large number of men; and these men work on a combined system under one central control.

The second variety, the 'cottage-clothier" system of the West Riding, is, however, the most characteristic of the three. Around each of the great towns of Leeds, Halifax, Bradford, Huddersfield, and Dewsbury, is a busy network of villages, all inhabited mainly by these clothiers. Here the actual workman is a small manufacturer on his own account, and frequently occupies a small farm, partly as a means of support, and partly for the convenience of the manufacture. His house contains from one to four looms, according to his means, as also carding and spinning apparatus; and he employs himself, his wife, and children, sometimes one or two of his neighbours, in making up cloth. He buys his own wool, brings it to a certain stage towards completion, and then carries it for sale to one of the great "Cloth-halls" in the towns above named. This clothier system has assumed an essentially different form in late years, approximating more nearly to the factory system. Thus, the clothier buys his wool, sends it to a mill, or kind of joint-stock factory owned by a number of clothiers, to be "scribbled," "carded," and "slubbed;" brings it home to be spun into yarn by his wife and children; weaves it into cloth himself; takes it to the mill to be "scoured" and fulled;" brings it home again to be carried one or two stages farther towards completion; and finally takes it to the cloth-hall for sale.

The cloth-halls of the West Riding are a kind of bazaar or market, open on certain days of the week for the meeting of buyers and sellers of cloth. In some towns they are for woollen cloths only, while in others they relate to worsted goods as well as to woollens. For instance, Bradford, the head-quarters of the worsted or stuff trade, has a "Stuff-hall," consisting of a spacious building, a hundred and forty feet long by forty broad, in which manufactured stuff goods are exposed for sale on market-days. At Halifax is a "Piece-hall," the largest building of the kind in the kingdom; it is a large freestone edifice, occupying an area of ten thousand square yards, and divided into three hundred shops, booths, or apartments, where the goods are exposed for sale; there have been frequently 50,000*l.* worth of woollen and worsted goods exposed here for sale at once. At Huddersfield there is a "Piece-hall" of rather remarkable construction: it is an extensive circular range of buildings, two stories in height, with a diametrical range one story high, dividing the internal area into two semicircles; the light is wholly admitted from within, there being no windows on the outside; the hall is subdivided into avenues, containing rows of stalls; and there are frequently six hundred country clothiers attend here on market-day. At Heckmondwicke, which with Dewsbury constitutes the centre of the blanket-weaving district, there is a "Blanket-hall" similar in its character to the Cloth-halls, Piece-halls, and Stuff-halls of the other towns.

We have yet to mention Leeds, a town which, being in many respects the head of them all, may fittingly illustrate the commerce of the district somewhat more in full. A century ago barges on the river Aire and laden pack-horses appear to have been the means of carrying cloth to Leeds market; for Dyer says:—

"Trade and business guide the living scene,
Roll the full cars adown the winding Aire,
Load the slow sailing barges, pile the pack
On the long tinkling train of slow-pac'd steeds."

In the earlier period of the cloth-trade at Leeds the market was held on the bridge over the Aire, on account of the publicity of the place, but at a later period it was removed farther north, into the heart of the town: here, during the early hours of market-mornings, the clothiers took their stand, to be succeeded at a later hour by the linendrapers and the shoemakers. But it was found that a building was necessary, to be expressly devoted to this purpose. The first cloth-hall is sketched in Fig. 463. Others succeeded it at different times; and at present there are two, known as the "White-cloth Hall" and the "Coloured-cloth Hall;" undyed cloth being sold in the one, and dyed cloth in the other. The Coloured-cloth Hall (Fig. 464) is a quadrangular building nearly four hundred feet long, divided into

six arcades or avenues, which receive such names as "Cheapside," "Change-Alley," &c. In each avenue are two rows of stalls or stands, numbering nearly two thousand in the whole building: each stall is inscribed with the name of the person who owns or rents it; and behind it is an open space where he stands surrounded by his goods on market-days. These days are Tuesdays and Saturdays. At about nine o'clock on these mornings the Hall opens, and the country clothiers arrive with their stock of cloth in laden carts. The clothiers station themselves behind their stands; and the merchants or dealers walk through the avenues, and inspect the cloths spread out on the stands: if any of the cloth suits the dealer, a bargain is soon struck as to quantity and price, and the buyer affixes his name to the piece bought. This kind of traffic continues about an hour and a quarter; at the end of which time the market closes, the clothiers send the cloth to the buyers, receive the money, and return to their homes the same evening. Immediately on the closing of the Coloured-cloth Hall, the White-cloth Hall opens; and an exactly similar course of proceeding follows. The persons who buy at these halls are either merchants who buy to sell again without embarking in any manufacturing arrangements, or they are manufacturers who dress and finish the cloth at their own factories before selling it: it being understood that the cloth sold at the halls is always in a rough and unfinished state; the country clothiers not having the means at command to finish it so cheaply as those who have factories and steam-power.

Such, then, are a few of the peculiar features observable in the woollen-cloth manufacture. Reserving, as in a former case, all notice of *dyeing* the cloth to a separate section, we may proceed to that department of wool manufacture belonging rather to the production of *worsteds* or *stuffs* than of woollens.

The Processes of Worsted Manufacture.

The wool employed for these purposes differs both in the length and the quality of the fibres from that used in the manufactures just noticed. But in many departments of the manufacture the processes are very much the same. Thus the spinning-wheels (Figs. 465, 466) of the domestic fire-side in country districts used to be pretty much the same whether flax, cotton, wool, or worsted were the object of attention. The allusions to this homely mode of spinning by our poets and early writers are numerous. Shakspere, in 'Twelfth Night,' makes the Duke say:—

> "Come, the song we had last night,
> Mark it, Cesario; it is old and plain;
> The spinsters and the knitters in the sun,
> And the free maids that weave their thread with bones,
> Do use to chant it."

As compared with the wool employed for woollen cloth, the long or combing-wool is characterised by strength and transparency, but is deficient in the power of felting. There are two varieties—the "long-combing" and the "short-combing"—both partaking of the class of worsteds, but in a different degree; the long-combing wool has an average length of about eight inches, and is used in the manufacture of hard yarn, and for other purposes in which length and firmness of fibre are requisite; whereas the "short-combing wool" is shorter, finer, and more disposed to felt, and is used for hosiery goods and for stuffs of soft texture. Fig. 467 shows the kind of sheep from which combing-wool is produced.

The processes which this wool undergoes in its transformation to worsted yarn, so far from being calculated to make the individual fibres lock into each other by the little roughnesses or teeth on the surface, are intended to facilitate the production of a fine, even, and smoothly-spun thread; and indeed the felting power of the wool is purposely injured or lessened in the earlier processes.

In the first place the wool is well washed from the adherent grease which it derives from the animal; this is done by working the wool in large vessels containing soap and water, and afterwards pressing out the water by drawing the wool between rollers or cylinders. The wool is then spread out on the floor of a heated room, to be speedily dried. Then commence the processes of disentanglement, in which the two machines described in a former page (Figs. 444, 445), and others depicted in Figs. 468, 469 are used, according to the kind of wool and the purposes to which it is to be applied. One of these machines is called a "plucker," and consists of a pair of spiked rollers connected with an endless apron or belt on which the wool is placed: this is one of the many forms of arrangement in which spikes or teeth help to smooth out and regulate the fibres. The first opening of the fibres being thus effected, they are either "carded" or "combed;" the former being a machine-process for the coarser wools, and the latter a hand-process for the finer. In hand-combing the workman uses a pair of comb-like instruments (Fig. 468). In a block or head are fixed a number of well-tempered, finely-pointed steel teeth, ranged in three rows differing somewhat in length. In order to facilitate the process, the combs are made hot: this is effected by placing the teeth into a small space left between two plates of a stove. The combs being heated, one of them is fixed in a post with the teeth uppermost; the wool is laid on the teeth; and the other comb combs it out. A homely but sufficient illustration of the process has been thus given:—"If we consider the full comb as the human head, disgraced by a quantity of neglected, long, and dishevelled hair, which we reduce to its elegant order, we shall have a very just idea of the operation and use of this instrument in the worsted manufacture. The very name shows its origin, application, and use."

The combing is also for some purposes effected by machines. One of the most efficient of these is sketched in Fig. 469. It consists of two large wheels, six or seven feet in diameter, rotating so that their edges may be nearly in contact. The circumference of each wheel is formed by a series of wires or teeth, on and between which the wool is placed: the wires on the one wheel comb out the wool on the other, and at the same time separate it into two portions—short fibres called *noils*, and long fibres called *tops*, which are afterwards used for different kinds of work. The short fibres are taken from the wheel by boys; while the long fibres leave the machine in a continuous but irregular string.

In all those varieties of the manufacture which require the wool to be carded, the processes bear considerable resemblance to the carding of cotton. The wool is first placed near a revolving cylinder called a *teazer*, whose external surface is studded with bent hooks; and these hooks, catching hold of the locks of wool, disentangle and open them, separating them fibre from fibre, and preparing them for the "cards." These cards are wires, much finer than the hooks of the teazer, disposed around the exterior of a long series of cylinders; the wool is caught from one cylinder to another twenty or thirty times in succession, whereby all its fibres become arranged very nearly in a parallel layer; and after leaving the last cylinder, it assumes the form of a delicate tender riband or "sliver," about ten inches in width. By this mode of dealing with the material, a great change has been wrought in the manufactured goods of Bradford, Halifax, and other towns where the combing-wools are employed. The *noil* of long-fleece wool and a great deal of skin-wool (that taken from the animal after being killed) which used to be employed only in blanket and coarse woollen work, can now be worked up into coarse worsted yarn; and the price has been so lessened by the change, that nearly all coarse worsted yarn is now produced by carding. The improvement has led to a vast increase in the consumption of wool within the last few years; for any fibres, however short, may be carded; whereas none under a length of six inches can be hand-combed; the result of which is that all the kinds of wool now reared in England can be spun into yarn of one kind or other.

From an inspection of the next five woodcuts (Figs. 470 to 474), and on comparison of them with others which have been before given, it will be seen that the processes of "drawing," "roving," and "spinning" the wool into worsted yarn, are very similar to the like-named processes in other manufactures. In the first place the wool, supposing it to have been "combed" by hand, is laid upon an endless band and carried between drawing rollers, by which it is elongated, ranged parallel, and conveyed in the form of a delicate riband into a cylindrical can. A repeated series of similar elongations and re-arrangements brings it to the state of a "roving," and then to that of yarn, fit to be used either by the weaver of stuffs and similar goods, or to be made into hosiery at the stocking-frame.

FLAX: ITS CULTIVATION AND MANUFACTURE INTO LINEN.

We have now arrived at the last of the four great staple materials for clothing, and shall find that though the growth and cultivation differ much from those of the other three, the manufacturing processes have considerable resemblance.

Almost all rude nations are acquainted with the use of some kind or other of vegetable fibre, which gives to them a substitute for the flax and hemp familiar to our own country. It will be well, then, to glance at a few of the

Substitutes for Flax.

It is believed that the ancient Greeks were acquainted with the use of the fibres of the *Spanish broom* (Fig. 475) for cloth and cordage. This plant springs forth on steep declivities and sterile land with a rapid growth. When cultivated it is readily raised from seed, which is sown in the high ground; the plants are left for three years; at the end of which time sprigs or young shoots are fit for use in making baskets. When the fibres are to be used for any such purposes as flax, the young plants are cut in August, spread out to dry, beaten with wooden mallets, and steeped for a few hours in water. When taken out of the water they are placed in a shallow pit, and covered with fern and straw. Every day for nine or ten days water is poured upon the heap of plants; and at the end of this time they are washed, and the thin green outer peel removed. The remainder of the stem is beaten, by which the fibres forming it are detached one from another. The fibres when dry are combed, sorted, and spun into yarn. The peasantry of the south of France avail themselves largely of this material; and it is indeed even said that in some departments the country people know no other cloth but such as is made from these fibres: each cottage producing its own requisite amount of cloth so spun and woven.

The Syrian *dog-bane* (Fig. 476) resembles rather cotton than flax, since it has a downy substance enveloping the seeds in the seed-pod. The fibres of this down are only an inch or two in length, and are with some difficulty manufactured into a kind of substitute for velvet and satin. The fibres of the stem are capable of being spun and woven like those of the Spanish broom.

The stem of the *hop-plant* is in some countries employed as a substitute for flax, and attempts have been made by the Society of Arts to encourage a similar plan in England. In Sweden the hop-stalks are gathered in autumn, and kept in water during the whole of the winter; in March they are taken out, dried in a stove, and prepared much in the same way as flax. The prepared filaments are fine, soft, and white, and are capable of being spun and woven into cloth. In one of the methods tried in this country, and described in the Transactions of the Society, the hop-bines were cut in lengths of two or three feet, and put into a copper containing ley in which linen had been previously bleached: they were boiled in the mixture till the rind separated easily. After this process the fibres were prepared in a manner similar to flax, but they were found very much more stubborn and harsh. The heckling was a troublesome operation, and carding was found preferable. The cloth produced from this, with heckled warp and carded weft, had the colour of tanned leather, and was bleached with difficulty; so that the manufacture does not seem very promising.

The stalk of the *nettle* and of the *bean* have been occasionally used for a similar purpose. The bean-haulm contains from twenty to twenty-five filaments running up on the outside; and these filaments, when separated by steeping and other processes, have been found serviceable for this object. The Rev. James Hall made a calculation to show how much material is lost that might be profitably applied in this respect. He found that on an average two hundredweight of bean-fibres could be obtained from an acre of ground planted with beans; that there are at least 200,000 acres of tick, horse, and other beans planted in Great Britain and Ireland; and that, therefore, from what is now disregarded as refuse 400,000 cwts., or more than 40,000,000 lbs. of good fibrous material might be obtained, which would furnish healthy employment to the cottager's wife and children.

The *hemp*-plant (Fig. 477) and *sunn*-plant (Fig. 478) alike yield fibres from their stems; but these are employed more particularly in the making of cordage, which will engage our attention in a future chapter.

The *bark* of trees, likewise, yields an abundant substitute for flax. The following account, taken from the volume of the 'Library of Entertaining Knowledge' relating to Vegetable Substances, will show how the inhabitants of Otaheite or Tahiti avail themselves of this kind of material.

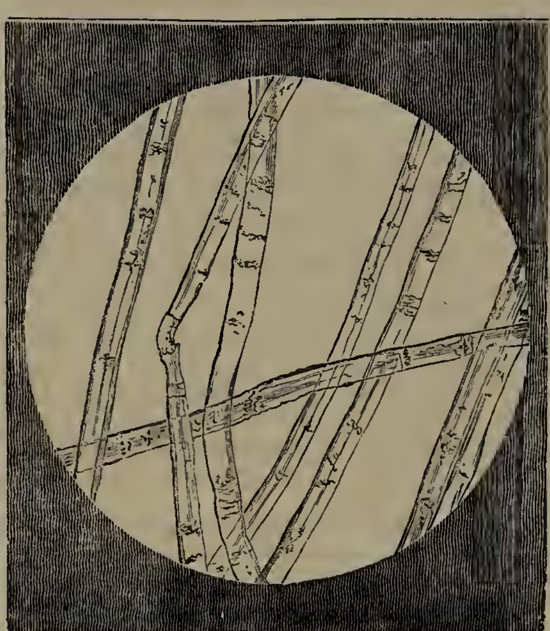
The Otaheitans make cloth of the bark of the paper mulberry-tree. The material from another kind, inferior to the first in whiteness and softness, is obtained from the bread-fruit tree. A third sort is made from a plant resembling a fig-tree; this is coarse and harsh, and of the colour of the darkest brown paper. Although apparently of an inferior description, it has a quality which renders it much more valuable in use than the others; namely, its resistance to water, in which the other two are deficient. In preparing the materials for these kinds of cloth the bark is not merely stripped off the trees as they grow in wild luxuriance, but the trees are carefully cultivated for the purpose of producing good and even bark. The lower leaves with their germs are taken off wherever they give any indication of producing a branch; as it constitutes the excellence of the trees to be thin, straight, tall, and without lower branches. The proper time for using them is when they are about six or eight feet high, and somewhat more than an inch in diameter. The plants are then drawn out of the ground, and stripped of their leaves and branches; after which the roots and tops are cut off, and the bark, being slit longitudinally, is readily separated from the stem. It is then placed in running water, and secured in this situation by placing heavy stones upon it. When sufficiently macerated, the inner bark is separated from the green outer rind. In performing this operation the women sit in the water, and placing the bark on a smooth board, scrape it with a shell: the fibres are found to separate more readily when immersed in water while being scraped; and the useless parts are washed away at the moment of their disengagement. This work is continued until nothing remains but the fine fibres of the inner coat.

The fibres thus prepared, they are worked up into a kind of cloth in a peculiar manner. The cleaned fibres are spread out on plantain leaves to the length of about

476.—Syrian Dog-bane: Substitute for Flax.

479.—Common Flax: Linum usitatissimum.

477.—Hemp: Cannabis sativa.



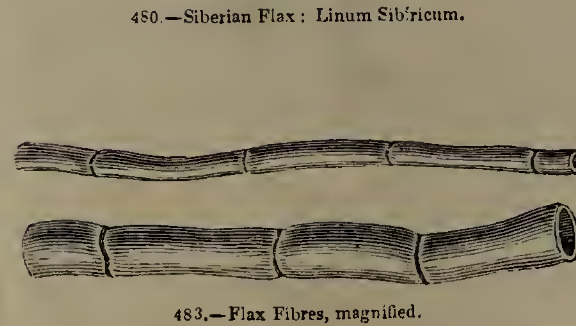
484.—Flax Fibres, magnified.

475.—Spanish Broom: Substitute for Flax.

482.—Flax Fibres, magnified.

480.—Siberian Flax: Linum Sibiricum.

481.—New Zealand Flax. Phormium tenax.

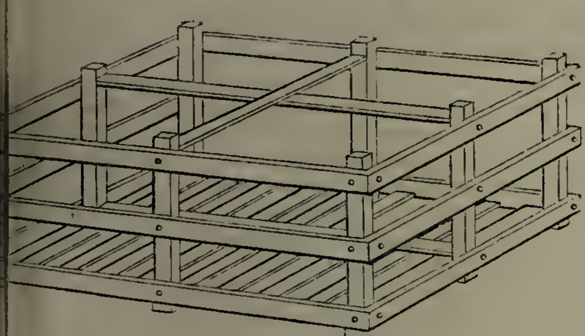


483.—Flax Fibres, magnified.

478.—Sunn. Substitute for Hemp.

490.—Flax-drawing.

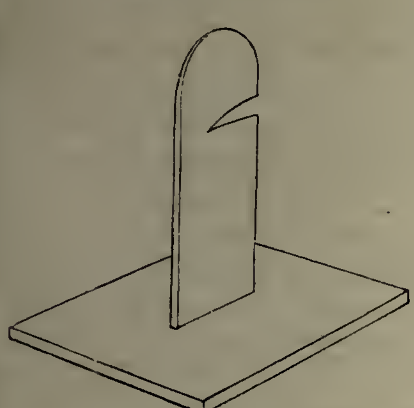
486.—Flax-breaking.



485.—Flax-steeping frame.

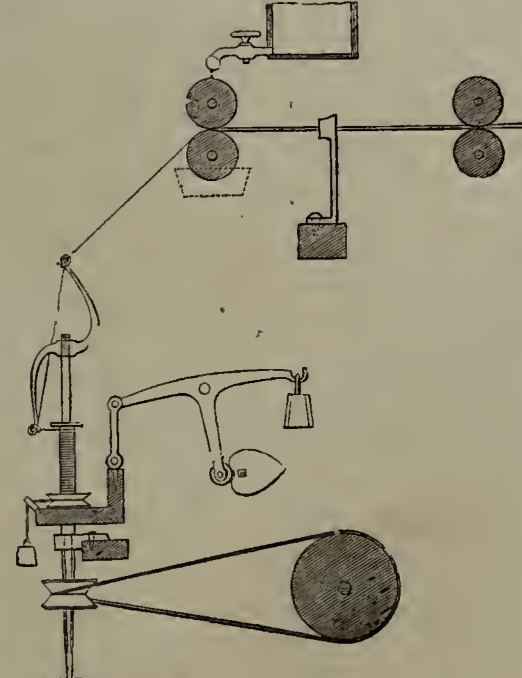
489.—Flax-heckling.

487.—Flax sword or scutcher.



488.—Flax-board.

491.—Flax-doubling.



493.—Wet Flax Spinning.

492.—Tow-carding.

eleven or twelve yards; these are placed on a regular and equal surface of about a foot in breadth. Two or three layers are thus placed one upon the other, much attention being paid to the equable arrangement of the whole. If in any one of the layers the bark happen to be thinner in one particular spot than another, a piece somewhat thicker is laid over that part in the next layer. This being completed, the united layer is left to dry during the night, when, great part of the moisture with which it had been saturated having evaporated, the several layers are found to adhere together, so as to allow of the whole being raised from the ground in one piece. It is then laid on a large smooth plank of wood prepared for the purpose, and beaten with a wooden instrument about a foot long by three inches square; each of the four sides of the instrument has longitudinal grooves of different degrees of fineness, the depth and width of those on one side being sufficient to receive a small packthread, the other sides being finer in a regular gradation; so that the grooves of the last side would scarcely admit anything coarser than sewing-silk. A large bundle being attached to this instrument, the cloth is beaten first with its coarsest side, and spreads very fast under its strokes: it is, after this, beaten with the other sides successively, and then is considered fit for use as cloth. Sometimes, however, it is made still thinner by beating it, after it has been several times doubled with the finest side of the mallet; and it thus will be attenuated to such a degree as to be very little thicker than muslin. The cloth will sometimes break while under this rough process; but the fracture is very readily repaired by applying a piece of the bark, which is made to adhere by a glutinous substance prepared from the root of one of these plants. This can be done with so much nicety, that the part which has been repaired can scarcely be distinguished from the rest. The cloth prepared in this very curious manner, especially when made from the bark of the mulberry-tree, is said to become extremely white by bleaching, to be tolerably durable, and to have a very good appearance.

Cultivation of Flax.

The flax-plant, used extensively for making linen in many countries, is one requiring great care in the cultivation. There are several species of it, of which two are here sketched—the *linum usitatissimum*, or common flax (Fig. 479); and the *linum Sibiricum*, or Siberian flax (Fig. 480). The New Zealand flax (Fig. 481) is so called without any reference to its botanical character: the fibres employed for making cloth are derived not from the stem, as in real flax, but from the leaf, and these fibres were at one time expected to become very valuable as a substitute for flax or hemp; but the cultivation, sale, and manufacture still continue very limited.

With respect to the flax-plant proper, the stems, when separated by steeping and other processes, exhibit a very fine fibrous structure; the nature of which, as viewed through a powerful microscope, is shown in Figs. 482, 483, 484.

The common flax-plant has a stem from a foot and a half to two feet in height, and a blue flower, which is succeeded by a capsule, containing ten flat oblong seeds of a brown colour, from which the well-known "linseed oil" is obtained. The best flax is obtained from Flanders, where the cultivation is particularly attended to; and we will condense, from the late Rev. Mr. Rham's description, a brief notice of the routine there followed.

After a certain rotation of crops, and a careful preparation of the ground, the linseed is sown broadcast, that is, strewed over the surface of the ground, about a hundredweight and a half to the acre. A bush-harrow or a hurdle is drawn lightly over the ground, to cover the seeds to a small depth with mould. In a short time the flax-plants come up thick and evenly, and with them also some weeds. As soon as the flax is a few inches high, the weeds are carefully taken out by women and children, who do this work on their hands and knees, both to see the weeds better and to avoid hurting the young plants: they tie coarse pieces of cloth round their knees, and creep on with their face to the wind, if possible; this is done that the tender flax, which has been bent down by creeping over it, may be assisted by the wind in rising again. When the flax begins to get yellow at the bottom of the stem it is time to gather it, if very fine flax for making cambric is desired; but a longer time if for other fabrics; and a yet longer time if the plant be cultivated chiefly for the oil of its seed.

The plants are pulled up by small handfuls at a time, and are laid upon the ground to dry, two and two, obliquely across each other; soon after this they are collected in larger bundles, and placed with the root end on the ground, the bundles being slightly tied near the seed end. When sufficiently dry they are tied more firmly in the middle, and stacked in long narrow stacks on the ground: the stacks are built as wide as the plants are long, and about eight or nine feet high, by twenty or thirty feet long. If the field be extensive, several of these stacks are formed at regular distances; they are carefully thatched at the top, and the ends, which are quite perpendicular, are kept up by means of the strong poles driven into the ground. Some of the growers steep their flax at once, without thus stacking it; but generally the steeping is left till the next season, the intervening winter being employed in beating out the seeds from the plants. In this liberation of the seeds, the plants are drawn through an iron comb fixed in a block of wood, whereby those capsules which are too long to pass between the teeth of the comb are broken off and fall into a basket or cloth below. Sometimes, if the capsules are brittle, the seed is beaten out by means of a flat wooden bat: the bundles of plants are held by the root end, while the other end is laid on a board, and turned round with the left hand, the right hand being employed in breaking the capsules with the bat.

The steeping of the flax is one of the most particular parts of the operation. The object of this process is to separate all the bark from the woody part of the stem, by dissolving a glutinous matter which causes it to adhere, and also by destroying some minute vessels interwoven with the longitudinal fibres: a certain fermentation, or incipient putrefaction, is excited by the steeping, which must be carefully watched, and stopped at the proper time. The usual mode of steeping in England is to place the bundles of flax horizontally in shallow pools or ditches of stagnant water, keeping them under water by means of poles or boards, with weights laid upon them; water nearly putrid is sometimes employed, but at the hazard of staining the flax. At Courtray, in Flanders, however, where flax-steeping is a distinct trade, matters are thus conducted:—The bundles of flax are placed alternately, with the seed end of the one to the root end of the other; as many of them being tied together at both ends as will form a bundle about a foot in diameter. A frame (Fig. 485), made of oak rails nailed to strong upright pieces, and forming a kind of open box about ten feet square by four deep, is filled with these bundles, set upright and closely packed: and is then immersed in the River Lys. Boards loaded with stones are placed upon the flax, till the whole is sunk a little under the surface of the water; the bottom does not reach the ground, so that the water flows both over and under it. There are posts driven in the river to keep the box in its place; and each steeper has a certain portion of the bank, which he calls his own. The flax takes somewhat longer time in steeping in this manner than it does in stagnant or putrid water; but the resulting colour of the flax is very much superior. When it is supposed that the flax has been steeped nearly enough, it is examined carefully every day, and towards the latter part of the period several times in the day, in order to ascertain whether the fibres readily separate from the wood throughout the whole length of the stem. As soon as this is the case the flax is taken out of the water; for the quality of the flax is injured by the steeping being either deficient or in excess only a few hours. The bundles are untied, and the flax is spread evenly in rows slightly overlapping each other, on a piece of clean smooth grass which has been mown close. Fine weather is essential to this part of the process, as rain would now much injure the flax. It is occasionally turned over, which is done dexterously by putting a long slender rod under the row, taking up the flax near the end which overlaps the next row, and turning it quite over: thus, when it is all turned it overlaps as before, but in a contrary direction. It remains spread out upon the grass for about a fortnight, till the woody part becomes brittle, and some of the finest fibres separate from it of their own accord. It is then taken up, and as soon as it is quite dry it is tied up again in bundles and carried into the barn, to be broken and heckled at leisure during the winter.

The object of all this train of operations is to bring the fibrous portion of the stem into such a state as to be separated easily from the woody portion within; and the different modes of conducting the flax culture in England, Ireland, Flanders, and elsewhere, all have relation to the bringing of the stems to the proper state. The question then arises, how to separate the fibres from the central woody portion of the stem? When the preparation of the flax is conducted by hand, the *breaking* and the *scutching* (two processes for effecting the separation) are thus conducted:—The "hand-break" (Fig. 486) is a block of wood five or six feet in length, by ten or twelve inches in width. Deep grooves are made in the wood, extending through its whole length, about an inch wide at bottom and increasing in width in such a manner that the divisions thus formed may present rather sharp edges on the surface. Over this block of wood another block is fitted, one end of it being made fast by means of a hinge, and the other shaped into a handle. This upper block has two longitudinal edges, so shaped as to enter and fit into the corresponding grooves of the under part of the machine. The flax-breaker, or workman who is employed at this machine, takes a quantity of flax in his left hand, while with his right he holds the handle of the upper jaw of the break. The flax being put between the upper and under part, the former is raised up and let down several times with great force; this breaks the stem or stalk, without injuring the fibres which surround it, and at the same time effectually separates these from the cellular tissue which united them, and which, together with them, formed the bark.

The "boon," or woody stalk, being thus broken into fragments, the next operation is to separate these fragments from the fibres. This, in the domestic method, is done by means of a "scutching-bat" (Fig. 487) and a "scutching-board" (Fig. 488). There is a board set upright in a block of wood, so as to stand steady, and in this board is a horizontal slit or notch. The broken flax, held by handfuls in the left hand, is inserted in this notch, so as to project towards the right; and a flat wooden wand or scutcher of a peculiar shape, held in the right hand, is used to strike the flax repeatedly close to the upright board; while the part which lies in the notch is continually changed by a movement of the left hand. This operation beats off all the pieces of the wood which still adhere to the fibre, without breaking it, and after a short time the flax is cleared and ready for further operations.

In the larger and more comprehensive operations of flax preparation, these processes of "breaking" and "scutching" are performed in a more rapid and efficient manner. A mill is employed, having three fluted cylinders, one of which is made to revolve by horse or water power, and carries the other two round. The flax-plants are placed between these cylinders while thus revolving, and the stalk is by this means completely broken without injuring the fibres. The scutching is accomplished in the same machine by means of four arms projecting from a horizontal axle, arranged so as to strike the stalk in a slanting direction until the bark and other useless parts of the plant are beaten away.

Before tracing the flax to the factories where it is spun into thread, it may be well to remark that our manufacturers cannot depend upon home culture for a supply. There are only a few parts of England where it is cultivated, and the quality of flax thus produced is not equal to that of Flanders. The linen trade being carried on rather extensively in the north of Ireland, it has been thought that a national good might be wrought by teaching the Irish farmers to carry on this branch of agriculture properly; and accordingly a society was formed for this purpose at Belfast in 1841. In a report, describing the state of things in the country districts of Ireland at that time, it is said:—"In the most fertile districts of the country the culture of flax is totally unknown; in others the crop is neglected; in some given up from partial failures; and even where regularly brought into rotation, its management is so little comprehended, as to yield little satisfaction to the consumer, and scarce half of those profits to the growers that it might do. The source of failures and reasons for non-accomplishment of this have now been clearly understood by intelligent parties to be attributable solely to carelessness, such as not properly preparing the ground, weeding, steeping, grassing, and swinging or clearing the flax; and these being all faults referable to the farmer himself, he willingly finds excuses, blaming seasons, water, or anything but his own ignorance or indolence, and rests perfectly satisfied that a crop of flax cannot be rendered as profitable here as on the Continent." As a means of imparting instruction to the Irish flax-growers, the newly formed society engaged two experienced Flemings to come over to Ireland and reside there some months, superintending the operations. Each year since then a report has been made of the proceedings; and good will probably result from them; but a considerable time must necessarily elapse before any notable change can take place in the mode of supply to the manufacturers.

Spinning Flax for Linen-Thread.

The flax-plants, then, after being so broken and beaten as to separate nearly all the central woody portion from the external fibres, are sent to market to be purchased by the flax-spinners. The fibres are wrapped up into the form of small bundles or "heads," measuring about two feet in length, and weighing two or three pounds each. The large buildings called "flax-factories," of which the most important are in or near the three towns of Leeds, Dundee, and Aberdeen, have a variety of machines for working up these fibres into the form of thread or yarn, by means of processes bearing more or less resemblance to those of the cotton-manufactories.

In the first place, the heads of flax, when opened, are "scutched" at the ends, that is they are fixed to a machine at one end, while the other end is rudely combed out. As the flax is in a much more dirty or dusty state than cotton or wool or silk, owing to the fragments of wood still adhering to it, all the early processes of flax preparation are extremely dusty, and it requires skilful arrangements on the part of the manufacturer to keep the work-rooms in a fit state for the operatives. When the ends of the flax are scutched, the fibres are cut into three pieces by means of a cutting machine, and the three lengths of each fibre are set aside for different purposes, the middle one being the best of the three.

Then ensues the process of "heckling" the flax, intended to separate, straighten, and cleanse

the fibres. This is done in two ways; either by "hand-heckles" or by "heckling-machines." The hand-heckle is a square piece of wood covered with iron teeth about four inches long; the fineness of the teeth and the distance at which they are arranged apart being chosen with reference to the quality of the flax. The heckler grasps a handful of the flax by the middle, and draws first one side or end, and then the other, through the teeth of the heckle, until all the little fragments of dirt and bark are removed, and the fibres become ranged smooth and parallel.

But the heckling-machines (Fig. 489) effect this in a more expeditious manner. Several such machines are placed in a row, and every handful of flax passes through all the machines in succession. Each machine has a cylinder, on the surface of which are a number of clasps or frames for holding the flax. The clasps are taken from the cylinders and placed on a bench, where boys are employed in fixing the flax into them by one end, leaving the fibres floating freely at the other. Girls are then employed to place the clasps on the surface of the cylinder, ranging them one by one round it. The cylinder being set in motion, the loose flax fibres are compelled to pass among and between a number of teeth fixed at a particular part of the machine, by which they become combed or heckled to a certain extent. The machine is then stopped, and the clasps with their flax are removed and placed upon a second machine containing teeth a little finer than those of the first machine. A second heckling is given to the fibres; after which they are removed to a third, a fourth, a fifth, and a sixth, each one having heckle-teeth finer than those of the one preceding it. When half the length of each group of fibres has been thus heckled, the flax is taken out of the clasps, and re-clasped at the other end, the end being now left free and flowing which had before been confined in the clasps. This end then undergoes the six consecutive hecklings as the other had done.

By this rather complicated process the flax has become very soft, silky, glossy, and free from every kind of dirt. As the fibres of flax are very different in quality among themselves, they are carefully sorted before undergoing any further preparation: every minute shade of difference in colour, fineness, and smoothness being attended to in this sorting or classification.

Next commence the processes more nearly belonging to the spinning of the flax. The individual fibres, still only a few inches long, have to be combined together in a continuous thread before they can be spun into yarn. To effect this the flax is laid on a smooth table or platform connected with the "drawing-machines" (Fig. 490), and is from thence drawn between small rollers, by which the fibres are combined into a continuous "sliver" or riband. The ribands so formed fall into cylindrical cans placed upright at one side of the machine. Each of these ribands is about an inch and a half in width, and presents a silvery and rather delicate appearance. To reduce it to the state of yarn or thread, the riband undergoes a long series of "doublings," "cardings," and "drawings." Several cans containing the ribands are placed together (Fig. 491), and the ribands are so drawn between rollers as to form one riband, thinner and narrower than the original ones, but very much longer; then these narrower ribands are carded and drawn, then doubled again, then carded and drawn, and so on several times, until at length the resulting product is a beautifully smooth band or narrow fillet of flax.

The workers in flax draw a distinction between "line" and "tow." As soon as the flax has passed through the heckling-machines it ceases to be called by its original name; the good portion is called "line," and the inferior "tow." The heckling-machines not only comb out the dirt and fragments, and range the fibres parallel, but they also remove the short and defective fibres, which remain adhering to the heckle-teeth. The short fibres so detached from the rest are, by a peculiar adaptation of the heckling-machine, removed from it in a state of a continuous sliver of *tow*, and this sliver, by being drawn, doubled, &c., is prepared for spinning in the same way as the "line," or better portion of flax. In some cases the loose tow, instead of being made into a continuous riband at the heckling-machine, is carded into that form by a separate piece of apparatus (Fig. 492).

Next comes the "roving," by which the "drawings" of flax are brought to the state of a loose, small, soft cord. This is done in the same manner as for cotton-roving. The spinning, however, so far differs from that of cotton, that the material is wetted before being spun. Flax-spinning is conducted on the "bobbin-and-fly" principle, and not on the "mule" principle. Besides the apparatus proper for spinning, there must be arrangements for wetting the thread. The object of this wetting is to produce a finer and smoother yarn than could result if the flax were dry; and one of the improvements of recent years has been to use warm water instead of cold, since it is found that the same flax, prepared in the same way, can be spun to a greater degree of fineness when wetted with warm water than with cold.

The arrangement of some portions of the spinning-mechanism is seen in section in Fig. 493, where water is seen to be flowing down upon the rollers through which the flax passes in the act of being spun. As the spindles or fliers revolve some thousands of times in a minute, there is a continual spray of water being thrown off by the yarn; and the spinners, to protect themselves from its effects, wear thick aprons. In the modern machines, where warm water is employed instead of cold, the water is contained in a trough attached to the machine, and is heated by steam admitted through a small pipe.

By such means the flax is brought into the form of yarn, and according as this yarn is to be employed for weaving into linen, or for sewing-thread, or for lace-thread, so is it treated after leaving the spinning-machines. If for weaving, it is reeled into hanks on a winding-machine, and then made up into bundles. If for sewing or for lace-work, two or more yarn-threads are doubled together, and spun or twisted into a thread of greater thickness and strength.

Commercial features of the Flax Manufacture.

The preparation and spinning of flax are carried on in factories, some of which are among the largest and most remarkable in the kingdom. Thus, Fig. 494 represents the interior of one which is in every way striking. The building is about four hundred feet long by two hundred broad, and consists of *one room*. This room is separated within into arcades by about fifty iron pillars, which support the ceiling or roof; and in this ceiling are sixty-five flattish domes, surmounted by conical skylights, which together present a surface of ten thousand feet of glass. Above the room, on the roof, is a grass plot and a garden laid out; there is a solid foundation of brickwork beneath the earth or mould, and the water which drains from the garden finds its way down the fifty iron pillars supporting the roof, which are made hollow for this purpose. Beneath this enormous room are vaults and passages provided with furnaces and other arrangements for warming and ventilating the building. Nothing else yet presented in English factories can equal the vast appearance of this noble room; and indeed it is probable (though we are not aware whether such is exactly the case) that no other single room in the world equals it in dimensions; the area being upwards of eighty thousand square feet. The object in having such a large room, instead of several rooms of smaller size, was for the convenience of supervision, for the facility of access to the machines, for proper ventilation, and for the maintenance of a uniform temperature, which is a point very essential to the proper spinning of flax.

The yarn spun in these factories is woven into several kinds of goods, of which linen is the principal. The weaving is carried on principally in three different districts: in the West Riding of Yorkshire, in Scotland, and in the north of Ireland. In Yorkshire the goods are woven chiefly by the hand-loom, and consist of *linen*, *duck*, *check*, *drabbet*, *tick*, *huckaback*, *diaper*, *drill*, and *towelling*. In Scotland, where power-looms have been extensively introduced, flax is woven into *shirting*, *damask*, and *table-linen* at Dunfermline; and into *sheeting*, *bagging*, *sacking*, *dowlas*, *sail-cloth*, *canvas* for floor-cloth, and other coarse goods, at Dundee.

In Ireland the goods woven are of various kinds, but the mode of conducting the manufacture partakes somewhat of the diversity of the clothier system in Yorkshire, described in a former page. At the beginning of the present century the custom was for each weaver to buy or raise and prepare his own materials, from which he made his linen or other goods, and sold it in the public market, or by private contract, to agents or travellers who went round the country for that purpose. Those weavers who had more than one loom employed persons of their own family, or apprentices, or neighbours, to work at them; and in such case the assistant was frequently paid by what was termed the "fourth penny;" that is, each workman received, as his remuneration for weaving a piece of cloth, the fourth part of the gross sum for which the cloth was sold. Out of the remaining three-fourths the owner of the loom derived his profit and the cost of the yarn. Many weavers were also small farmers: the preparing and spinning of the flax were undertaken by the females of the family, while the man and his sons worked either at the loom or in the field, according to the season and the prospects of advantage. At the present day the arrangements partake of far different varieties. Sometimes the weaver works on his own account, holding at the same time a small piece of land; sometimes the weaver is a "cottier," who works for manufacturers without holding land; sometimes he works for manufacturers, and at the same time rents a farm; while, as a fourth variety, and one which is fast superseding the other three, the weaver works for a manufacturer in a weaving-shop or factory.

There is a peculiar feature observable in one particular district of the metropolis, exemplifying one of the uses to which coarse sacking is applied: it is true that the sacking here alluded to is made of hemp rather than of flax, but it is closely connected with our subject. On London Bridge may daily be seen women walking rapidly along, and carrying on their heads large bundles of sacking (Fig. 495). On the Southwark side of the Thames are a large number of wool-dealers, corn-dealers, hop-dealers, and others, who require to be provided with strong sacks and bags; and the demand thus created gives rise to the employment of sack and bag makers, and sack and bag *hire* warehouses. The makers procure the canvas from Scotland, cut it up into pieces of the proper size, and the women above alluded to go to and from the warehouses, bringing loads of canvas to work up into sacks at their own poor dwellings, and carrying the finished goods back to the warehouse.

WEAVING: ITS VARIETIES AND ITS ACCOMPANYING PROCESSES.

The point has been at length reached when we can gather up the scattered threads of our details, and follow them out collectively to their common results. We have seen how the cotton-spinner, by his "wheel" and his "frame," his "mule" and his "throstle," brings the cotton to the state of fine yarn; how the silk-throwster gives coherence and strength to the delicate filament elaborated by the silk-worm; how the woollen-spinner and the worsted-spinner give to the fleece of the sheep the form of thread more or less endowed with the felting property; and how the flax-spinner brings the enveloping fibres of the flax-plant to the state of yarn or thread. Let us then next see how these spun materials are woven up into cloth.

If a piece of woven material, of any of the common kinds, be picked to pieces or closely examined, it will be seen that there are two sets of threads, crossing each other at right angles; and that the strength and firmness which the cloth possesses results from the interlocking of these threads, those which pass in one direction being made to go alternately over and under those extending in the other direction. It will further be observed, that the appearance of the cloth suffers a good deal of diversity according to the order or system in which the interlocking occurs. If a piece of linen, or of calico, or of plain silk, or of plain merino be examined, it will be found that the cross-threads go over a long or warp thread, then under the next one, then over the third, under the fourth, and so on, changing at every thread individually. But in the more figured or fancy goods, this alternation is by no means so regular. In *twills*, for example, whatever be the material (for the word twill has relation to the mode of weaving, and not to the material of the cloth) the weft or cross thread passes over one warp or long thread, under two, three, or more, over one, under two or more, and so on; always passing under more threads than it passes over. Sometimes the number of threads thus passed at once is as large as six, eight, or ten. One consequence of this mode of intersection is that there is a diagonal ribbed appearance on the face or upper surface of twilled goods, while the back or lower surface exhibits a kind of loose texture or flushing. We may give something like a rude explanation of this by means of Fig. 496, where we are supposed to see a piece of twilled cloth *edgewise*: the round black spots represent sections of the warp-threads; while the white line represents a weft-thread, passing first under or over four warp-threads, and then under or over one. In plain twilled goods the weft usually passes under more threads than it passes over; but here it will be seen that the system alternates, the groups of four being sometimes under and sometimes over. One result of this alternation is to give figured patterns to the cloth, such as are seen in dimity or diaper, while the more simple alternation gives rise to the kerseymere kind of texture. Other kinds, such as *gauze*, have the warp-threads twisted around each other after every intersection of the weft. In Fig. 497, for instance, the black lines may represent the warp-threads twisted round each other, while the white lines may represent the weft-threads passing between and among them.

Processes preparatory to Weaving.

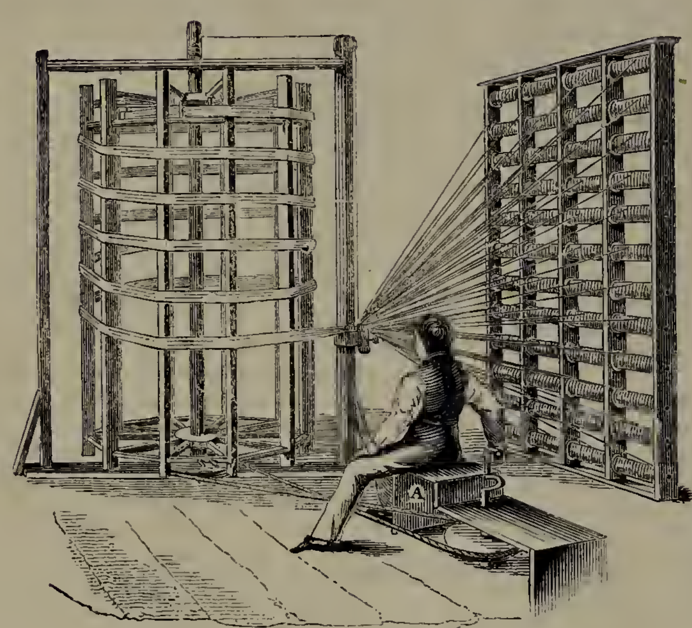
This being the nature of weaving, there is abundant evidence to show that the practice of the art has been carried on from very early times. We have had occasion to allude to this before, and shall not require to accumulate evidence of the fact. Before the actual weaving there are three or four preparatory processes, which it may be well to notice shortly.

One of these is the process of *warping*, the nature and object of which may be very readily understood. As the hanks of spun material, whether cotton or any other, are wrapped up closely, the yarn requires to be stretched out and laid parallel before it is fitted to act as warp for the woven cloth; and this process of arranging it is called warping. There have been, at different periods in the history of weaving, four different modes of performing this process; by the aid of the warping-field, the warping-frame, the warping-mill, and the warping-machine. In the first and most ancient of these, the warp is removed from the bobbins

496.—Diaper and Kerseymere.

494.— Interior of Marshall's Flax-Mill, Leeds.

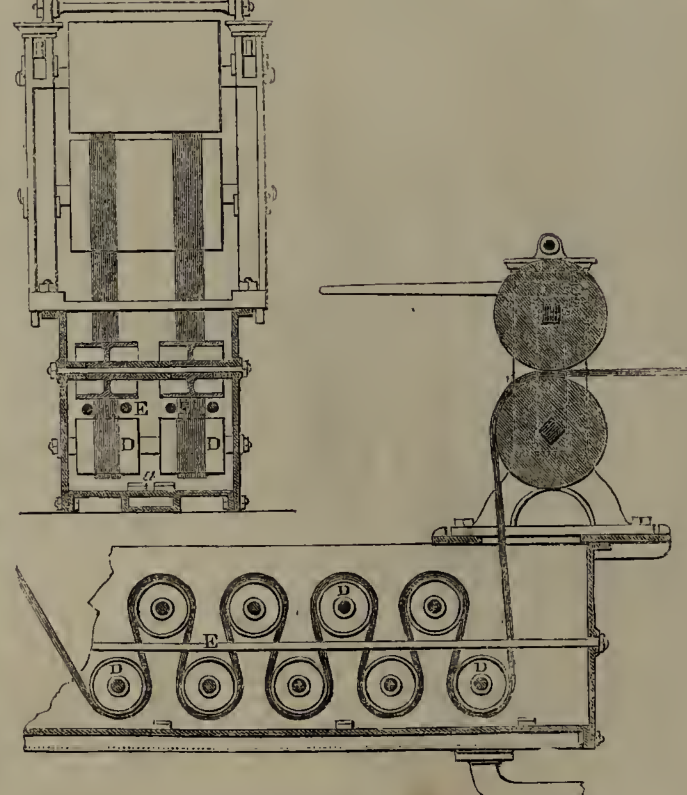
497.—Gauze.



499.—Warping-yarn for Muslin.

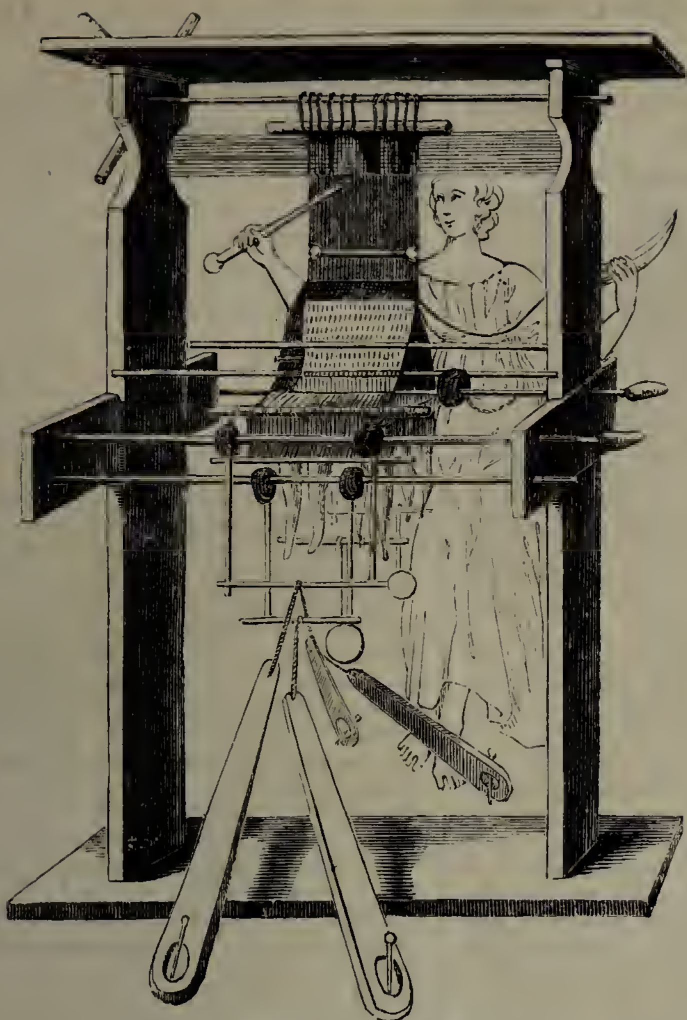
495.—Bermondsey Sack and Bag Women.

501.—" Drawing in " Worsted Warp for Weaving.



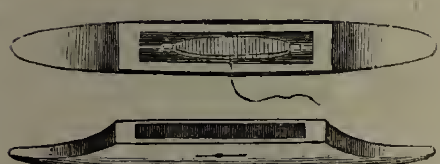
500.—Yarn-sizing Machine.

498.—Ancient Warping-frame. (From Montfaucon.)

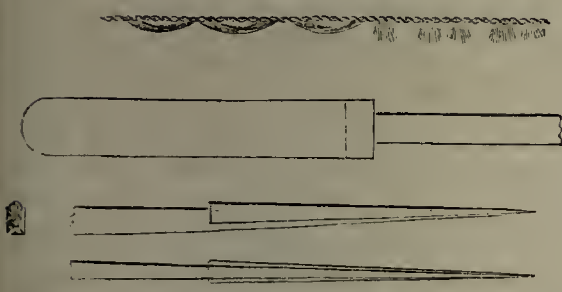


505.—Ancient Loom. (From Montfaucon.)

509.—Hindoo Weaver at work in a Field.



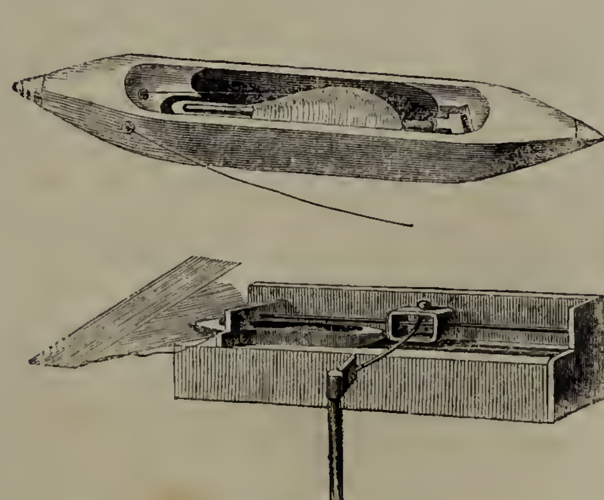
504.—Shuttle used by the Cingalese.



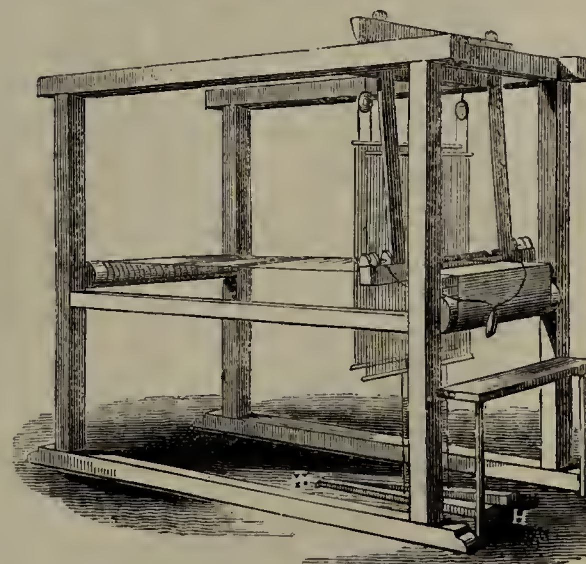
502.—Knives for cutting Fustian.

507.—Clothier's Looms in the Eighteenth Century. (From Hogarth's 'Industry and Idleness.')

506.—Flemish Weaver. (From a Print of 1568.)



503.—Shuttle of Power-loom.



508. Common Hand-loom.

by hand, and stretched out in an open field. Dyer, in his poem of the 'Fleece,' mentions this mode of warping as if it were customarily practised in his day in England, for he describes the warper occupied as he

"strains the warp
Along the garden walk, or highway side,
Smoothing each thread."

The *warping-frame* is a large wooden frame, fixed upright either against the wall or on a stand. The sides of the frame are pierced with holes to receive wooden pins, which project sufficiently to receive a large number of yarns. The warper arranges in an adjoining piece of apparatus as many bobbins of yarn as there are to be threads in his warp. He ties the ends of all the threads together, and walks to and fro before the frame, passing the clue or group of yarns over all the pegs in succession. The bobbins unwind as he proceeds; and the yarn slips through his hand as he walks along. When all is completed, he takes the yarns off the pegs; and has then grouped into a long loose roll, as many threads as will form his warp. Some of the ancient representations connected with the clothing arts, such as that in Fig. 498, from Montfaucon, represent a small kind of warping-frame, with indications seeming to show that in weaving the warp was arranged vertical, instead of horizontal as with us.

Another and more efficient mode of warping is by the aid of the *warping-mill*, of which one form is seen in Fig. 499. There are here two frames or machines, and a winding-apparatus placed near them. The bobbins are placed in an upright frame, in such a way that the yarn can readily unwind from them. The yarns from all the bobbins, collected together in a group at one spot, are attached to the frame whereon they are to be wound. The warper, sitting on a stool, sets a kind of hollow vertical frame in revolution by means of a handle and rope, and by so doing causes all the yarns to be unwound from the bobbins, and re-wound on the vertical reel. By a peculiar arrangement of the apparatus, the clue of yarns is wound spirally round the reel, from which it is at length removed in a continuous group.

In the *warping-machine*, connected with power-loom weaving, the warping and other processes are conducted pretty much at the same time. The bobbins containing the yarn are ranged with their axes horizontal and parallel. The yarns are drawn from the bobbins, made to pass under some rollers and over others, and are at length brought into a parallel layer, with a comb or grating of fine wires so employed as to separate the yarns in an equidistant manner. After having so passed, the yarns are made to coil round a roller or beam, and are in that state removed from the machine.

So far, then, the object has been to collect together as many threads as will form the warp of the cloth, but without arranging them in the loom where they are to be woven. But cotton goods require a certain kind of "dressing" or "sizing" before being woven, in order to give the warp-threads the proper degree of stiffness. In hand-loom weaving the warp-yarns are dressed as the weaver proceeds: he suspends his operation from time to time, clears away knots and burs from his warp by a kind of comb, lays on a warm coating of paste or size with a brush, and dries the paste by a current of air excited by a large fan. In the power-weaving method, however, eight rollers, containing yarn which has been warped, are so placed that the yarn from them may, when unwinding, pass between two rollers before being transferred to a larger beam; and as the lowermost of these two rollers revolves in a trough containing paste, the yarns become coated with paste by this means. They next pass over and under brushes, by which the paste is rubbed into the fibres of the yarn; and after this they pass over hollow cylinders heated by steam, by which they are quickly dried. Sometimes, for particular purposes, the yarns are sized, instead of dressed, by means of the machine sketched in Fig. 500, of which the upper or left-hand portion represents the section in one direction, and the lower or right-hand portion the section at right angles to the former. There is a large trough filled with melted size, through which the warp is made to pass. There are several rollers, D, immersed in the size, and several more above them; and the yarn, E, travels over all of them, being alternately wetted and pressed.

The "beaming," the "drawing in," and the "winding," are other processes intended to prepare the yarn for the purposes of the weaver. In beaming, the yarns which had previously been warped are coiled round a large beam belonging to the weaving-loom, and are ranged as parallel and even as possible. In "drawing in" (Fig. 501), parts of the warp are loosened or unwound from the beam, and women prepare it for the reception of loops or eyes essential to the working of the loom. In "winding," as applied to the weft-threads and not to the warp, the yarn is unwound from the bobbins, and re-wound upon a little pin or axis running through the shuttle. This shuttle is a little boat-like instrument (Fig. 504, and upper part of 503) having a recess in which this pin or axis revolves; and has also a small hole so adjusted that the yarn may unwind from the pin, and leave the shuttle as fast as it is wanted for the weaving process.

These are the chief of the operations preliminary to weaving, and they will receive their proper elucidation while speaking of the weaving itself.

Weaving as practised by rude Nations.

We have had occasion before to speak of the textile or clothing arts as developed in early times and in rude or semi-civilized countries in the present day; and we may here give a few further illustrations in respect to weaving especially. Sir J. G. Wilkinson has found among the monuments of Egypt representations of the looms used by that remarkable people in early times. He states, on the one hand, that these looms appear to have been exceedingly rude in construction; while, on the other hand, he notices the fact that the Egyptians, from a remote æra, "were celebrated for their manufacture of linen and other cloths, and the produce of their looms was exported to and eagerly purchased by foreign nations: the fine linen and embroidered work, the yarn and woollen stuffs, of the upper and lower country, are frequently mentioned, and were highly esteemed." It might seem contradictory to speak of the rudeness of the looms, and at the same time of the excellence of the produce; but the example of the Hindoos shows us that delicacy of touch may go far to compensate for deficiency of mechanical aid. The writer here quoted, speaking of the proofs that figure-weaving was known to the early Egyptians, says:—"Some portions of woollen-work have been found at Thebes, which presented the appearance of a carpet: and a small rug was lately brought to England, and is now in the possession of Mr. Hay. This rug is eleven inches long by nine broad. It is made like many carpets of the present day, with woollen threads on linen string. In the centre is the figure of a boy in white, with a goose; above it the hieroglyphic of a 'child' upon a green ground; around which is a border composed of red and blue lines; the remainder is a ground of yellow with four white figures above and below, and one on each side, with blue outlines and red ornaments; and the outer border is made up of red, white, and blue lines, with a fancy device projecting from it with a triangular summit which extends entirely round the edge of the carpet. Its date is uncertain; but from the child, the combination of the colours, and the arrangement of the border, I am inclined to think it really Egyptian. I have also been informed by Lord Prudhoe that in the Turin Museum he met with some specimens of worsted worked upon linen, in which the linen threads of the weft had been picked out and the coloured worsted sewed in the warp."

There was for a long time a good deal of doubt concerning the material from which the mummy-cloths of Egypt were made; but it is now known that they were made of linen or flaxen cloth. Mr. Thomson of Clitheroe, one of the most scientific among our manufacturers, has examined many specimens of mummy-cloth with a view of determining how it was woven. In one specimen he found that the texture was close and firm, yet elastic; the yarn, both of warp and of weft, was remarkably even and well spun; the weft was single, while the warp-yarn consisted of two threads doubled together; and it was observable in that, as well as in other specimens, that the number of threads to an inch in the warp uniformly exceeded that in the weft—a difference not usually found in European woven goods. In more specimens, brought to England by Salt and Belzoni, Mr. Thomson found that the "selvages" were well made; that striped goods, similar to modern ginghams, were often made by the Egyptians; and that indigo was used as one of the dyes. From some of the pictures found at Thebes, and other parts of Lower Egypt, it appears that the loom was sometimes horizontal, but generally vertical, and that the shuttle was almost half a yard in length.

The looms used by the Greeks and Romans seem to have had the warp-threads ranged vertically, like those in Fig. 505, which is copied from a curious old engraving in Montfaucon; and the methods appear to have been known whereby the varieties of weaving known by us as "checks" and "stripes" could be produced.

When we transfer our attention to Oriental countries, as presented to our notice at the present day, we find that the looms have the warp-threads ranged horizontally, as with us, but that the subsidiary arrangements are much more primitive and rude. This may be illustrated by three among the sketches of looms given in the woodcuts, viz. (Figs. 509, 509*, 516), in three successive pages. In the first and second of these, the Hindoo method of weaving is represented; the one in the open air, and the other in a shed. The weaver digs a hole in the ground to receive his legs while sitting, and fastens his simple apparatus to trees, or branches, or pegs, just as may happen to be convenient. The system may, however, best be illustrated by Fig. 516, which represents the mode in which the inhabitants of Ceylon weave their cloth. A gentlemen who had personally witnessed the processes in Ceylon, gave a description of them in the second volume of the 'Penny Magazine;' and we cannot do better than follow this description.

"On the 5th of January, 1821, two Candyan (the capital of Ceylon is named Kandy or Candy) weavers came to the general hospital, with all their implements for weaving, for Mr. Marshall's and my inspection. I showed them into a kind of open shed, with which they seemed pleased; and here they established their manufactory. They commenced their operations by driving four rude posts into the ground, and left them about thirteen inches high; they were, as it turned out afterwards, for the support of the breast-beam, which was square; and the other supported a flat board for the purpose of raising the web a little behind the treadles. The breast-beam had a groove cut into it, for the purpose of fixing the end of the web in, but by filling it with water it answered as a level. Their mode of levelling the two beams with each other was by placing a slip of the rind of a plantain-tree upon them, and pouring water upon the centre, any inclination was ascertained with great accuracy. Between the four posts a hole was now dug, a little more than knee-deep, in which the weaver was to put his feet when working, sitting upon the edge of the hole.

"Nothing could be more rude or simple than the different articles used; and some idea may be formed of them when I state that the loom, including everything employed in weaving, is purchased for something less than half-a-crown. The warp had been previously put into the treadles and reed. No beam for the warp is used, but the whole reached within a few inches of the ground at once. From the extremity of the web a cord is extended round several stakes driven into the ground, and at last is fixed by a sailor's knot (the clove hitch) to a post close to the weaver, who, by slacking off a little, as occasion requires, by degrees draws the arm over part of the web towards himself; several rods (lease-bands) are run through the warp for the purpose of steadying the threads and preserving the shade or lease, and are drawn out as the web advances. The treadles had only two leaves; instead of treadles, two cords descended into the hole, with a piece of lead attached to each, and this was taken between the two first toes, and so worked. The lay is suspended between two coarse cords: it consists of two pieces of board, with a groove in each for the reception of the reed, which is retained by a cord at each end. The shuttle resembles that used in Britain in weaving woollen. At seven o'clock A.M. the loom was tied up, and at nine A.M. he was weaving with great rapidity. The warp was very coarse, but regular, and had been dressed before he came. Rice boiled in water is the substance used for this purpose, and it is applied by means of a bit of rag. I detained the operator for several hours in taking sketches, yet he finished his work by two P.M. It might be three yards long, and the weaving cost nearly sixpence. The weaver seemed to possess a large share of vanity, and was much pleased to show that he could weave with his eyes shut. The weavers are of a very low caste: on going in he used to fall flat, and there keep knocking his head upon the ground.

"Another important personage remains to be mentioned: his duties were those of a pirn-winder and assistant. He was a much younger man than the principal. His implements were, if possible, more rude than those already mentioned. The woof (weft) was brought in a leaf, and was wringing wet with thick congi-water (fluid paste); it was done in hanks or skeins of about eight inches in diameter. The machine corresponding with the 'swifts' (used in silk-winding) was formed by splitting a bamboo into six portions, within three inches of one end; these splits were kept asunder at the lower end by means of a hoop. The bamboo was twenty inches in length. A thin rod was driven into the ground, and the bamboo rested upon and revolved round it. The winder kept five or six pirns only ahead of the weaver; but whenever a thread of the web broke, it was his duty to get up and tie it; and indeed he had to do everything out of the reach of the weaver, who could not get out of his hole without unshipping the breast-beam. Thus they went on very sociably together, always working, chewing betel, and conversing. I understand their manner of warping is performed by fixing sticks in the ground at certain distances, and leading the yarn round them which had been put upon the split bamboo, as in filling the pirns and centre stick held in the hand. The yarn is spun by women, with the distaff."

Here, then, we have evidence that the inhabitants of Asia are able, by very simple contrivances, to produce linen fabrics fitted for general purposes. The particular parts of the apparatus essential to every loom, we shall best understand by tracing them in connection with

The Hand-Loom, and Hand-Loom Weaving.

A common hand-loom (such as sketched in Fig. 508) consists of several parts, some of which are required to keep the warp-threads extended to their proper length; some to spread them out to the proper width; some to separate them into two parcels, according as the weft-thread is to pass over or under them; some to make these two parcels alternate in their movement up and down; some to drive up every weft-thread close to the one before introduced, before throwing in another; some to wind up the woven cloth as fast as it is made, and to unwind more warp from another part of the machine.

At the further part of the machine is a cylindrical beam or roller, fixed by pivots at each end so as to revolve; this is the "warp-beam," on which the yarn forming the warp is wound. The warp from this beam is capable of being drawn out into a horizontal layer, stretched across to the foremost end of the loom. Suspended vertically from about the middle of the machine are a series of strings; there are two sets or leaves of "treadles," each leaf consisting of a number of strings ranged vertically, attached at the bottom to two treadles, on which the weaver places his feet, and at the top to a cross-bar. Each string has, near its middle, a loop or eye, through which the warp-yarns are drawn. The yarns of one parcel, consisting of every alternate yarn throughout the layer or series, pass through the loops in one leaf of treadles: while those of the other parcel pass through the loops of the second treadle; and as these two vertical treadles, or groups of strings, are so connected that one sinks when the other rises, and *vice versâ*, the warp-threads are necessarily separated into two sets, each set forming a layer alternating above and below the other. There is thus an opening formed between the two sets of warp-threads, and into this opening, called the "shed," the shuttle is thrown containing the thread which is to constitute the weft, or "cross-thread."

In the lower part of Fig. 503, for example, there is a small portion of this divided warp shown, with the point of the shuttle just about to enter it.

Such, then, being the chief component parts of the loom, the manner in which they are brought to bear on the object in view is as follows:—The weaver sits at the front end of the loom, and presses down with his foot one of the two treadles; by which action one of the two halves or groups of the warp is depressed, thereby forming the shed. Into this shed he throws the shuttle with one hand (say, the right) with sufficient force to drive it completely through the shed, and out at the other side. He catches the shuttle in his left hand, and with his right grasps the "batten," which is a kind of frame, carrying at its lower edge a sort of comb, having as many teeth as there are threads in the warp: this batten, when pulled towards the weaver, drives up the thread of weft close to those previously thrown. All the operations connected with the introduction of one thread of weft are now completed; and the weaver proceeds to throw in another thread, but reversing the action of his hands and feet. He presses down the treadle which had before been raised, and raises that which had before been depressed; and the groups of warp-threads becoming thus reversed in position, he throws the shuttle with his left hand towards his right, instead of from the right to the left; he drives up the weft-thread, by means of the batten, with his right hand, instead of his left as before. This completes the second stage; and he then commences with the third stage similarly to the first; then the fourth similarly to the second, and so on. When he has intersected a sufficient number of threads of weft among the warp to make a few inches of cloth, he winds this cloth on the "cloth-beam" in the front of the machine, unwinding at the same time an equivalent length of warp from the "warp-beam" at the back of the machine.

Contrivances have been at different times introduced for facilitating the throwing of the shuttle in weaving. In the commonest modes of proceeding the shuttle is, as we have just described, thrown alternately with both hands; but in the "fly-shuttle" there is a string and a handle so placed that the weaver can work the shuttle both ways with one hand. The shuttle, and the apparatus connected with it, represented in the lower part of Fig. 503, are connected with power-loom weaving, to which we shall presently direct our attention.

There are numberless old engravings extant exhibiting the common hand-loom under a form approaching more or less nearly to that just described. In Fig. 506, for instance, we have, from a print by Schopfer, published at Frankfort nearly three centuries ago, a Flemish weaver working at his loom. The heddles, the treadles, the batten, the shuttle, the cloth-beam—all are there; and by the side of him appears to be a pan and brush for "dressing" the warp with paste. A woman seems to be bringing him yarn; and there is more yarn in a basket behind him.

Hogarth, who attended with such wonderful minuteness to the accessories which might enable his pictures to tell their own tale, and to work out a history of manners, has not left us in the dark concerning the clothiers' looms of his day. In his series on 'Industry and Idleness' there is one (Fig. 507) in which two such looms are shown. Here we can trace the warp-beam, the cloth-beam, the treadles (the heddles are hidden behind other parts of the mechanism), the batten, and the shuttle. On the floor, too, are a reel and a wheel for winding the yarn on the pirn of the spindles. The *moral* illustrated by the two apprentices sitting at the looms has been thus pointed out in one of the early volumes of the 'Penny Magazine:'—"The one, whose open, modest, and intelligent countenance at once wins our regard, is carefully intent upon the duties of his occupation; the other, whose vulgar and unintellectual face is indicative of the habitual progress of his character, is fast asleep. The pewter-pot on the loom and the tobacco-pipe by its side show that his drowsiness proceeds from indulgence rather than from fatigue. He is equally indifferent to the noise of the cat who is playing with his shuttle, and to the angry step of his master, who is entering the door with a cane uplifted for his chastisement. The accessories of the scene are few and simple, but they assist the development of its characters. The industrious apprentice has fixed upon the wall some papers which may incite him to preserve in his course of diligence, such as the 'Life of Whittington:' the idler has stuck up a profane ballad of that day, called 'Moll Flanders.' The 'Prentice's Guide' of the one is carefully preserved; that of the other is torn and dirty. The artist, in this first plate of his series, has made the difference of the two characters that he intends to contrast in their conduct and their fortunes perfectly intelligible. He has strikingly availed himself of the general inclination to associate certain qualities of the mind with certain forms of countenance and modes of expression."

Power-loom Weaving.

It is not remarkable that, at the time when the mode of spinning cotton underwent such wonderful changes towards the end of the last century, the processes of weaving should also have been subjected to examination, with a view of discovering some mode of hastening those processes, and enabling them to keep pace with the altered state of things. We shall find accordingly that such attempts were made, and that they were ultimately most highly successful.

As long ago as the year 1678, ingenuity was directed towards the invention of some machine which should weave cloth simply by the turning of a wheel. M. de Gennes described, in the 'Philosophical Transactions' of that year, a machine having this object in view, or rather, he mentioned the fact of such a machine having been devised, but the particular mode of action was not clearly explained. He designated it "a new engine to make linen cloth without the aid of an artificer;" and stated its excellences to be as follows:—"That one water-mill alone will set ten or twelve of these looms at work; that the cloth may be made of what breadth you please, or at least much broader than any which has been hitherto made; that there will be fewer knots in the cloth, since the threads will not break so fast as in other looms, because the shuttle, that breaks the greater part, can never touch them; in short, the work will be carried on quicker and at less expense, since, instead of several workmen, who are required in making up of very large cloths, one boy will serve to tie the threads of several looms as fast as they break, and to order the quills in the shuttle." If such important advantages were presented by this machine, it is strange that the new loom itself did not come into use: but as we hear little or nothing more of it, we may conclude that the inventor had somewhat over-rated the merits of his own contrivance.

During the last century many projects were started by ingenious mechanicians to shorten in some way or other the process of weaving; and the Museum of the Society of Arts contains at this time a model of one of the machines so contrived by Mr. Austin. But the most notable step in this direction was taken by Dr. Cartwright (Fig. 510), who, though not so fortunate as to carry out to his own profit the result of his ingenuity, laid the foundation for a successful prosecution of the method on the part of others. He has left a curious account of the circumstances under which he was led to turn his attention to this matter.

Dr. Cartwright (who was the brother of the late Major Cartwright), in a letter to Mr. Bannatyne, thus relates the matter:—"Happening to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning-machinery. One of the company observed that, as soon as Arkwright's patent expired, so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a weaving machine or mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer or even to comprehend, being totally ignorant of the subject, having never seen a person weave. I controverted, however, the impracticability of the thing by remarking, that there had lately been exhibited in London an automaton figure which played at chess. 'Now you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game?' Some little time afterwards, a particular circumstance recalling this conversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of the business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail-cloth is usually made of. To my great delight a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to anything mechanical, either in theory or in practice, nor had ever seen a loom at work, or knew anything of its construction, you may readily suppose that my first loom was a most rude piece of machinery. The warp was placed perpendicularly, the reed fell with the weight of at least half a hundredweight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property, by a patent 4th April, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles nearly as they are now made. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st of that year."

Dr. Cartwright, after this, tried to establish a power-loom weaving-factory at Doncaster, but failed; many other similar attempts failed; and after spending many years and a large fortune, he obtained from Parliament a reward of 10,000*l.*, as an acknowledgment of the national value of an invention which had brought no profit to its author. One reason why the machine failed for a long time in its object arose out of the circumstance that cotton (the material to which the power-loom, until recent years, was exclusively applied) requires dressing while being woven, and that the wages paid to the man who had from time to time to dress the warp went very far to counterbalance all the economical advantages belonging to the power-loom itself. At length Mr. Radcliffe, of Stockport, invented the dressing frame or machine, by which the yarn is dressed before being placed in the loom.

We may now see wherein consists the main principle of this important piece of machinery, improved as it has been by the inventions of many persons in succession, particularly Mr. Roberts of Manchester. In Fig. 511 we find the chief effective mechanism of the power-loom displayed, divested of all save the weaving parts. At the bottom, on the right-hand side, is a cylindrical roller, or beam, containing the warp. The warp, when unwound, passes over a smaller roller above, and extends onwards towards the left hand of the figure. In its passage it passes through the loops of two heddles suspended from rollers above, and the threads of the warp are by these heddles so separated into two groups as to form a shed into which the shuttle is thrown. At the extremity, on the left hand, the woven cloth is wrapped round the cloth-beam.

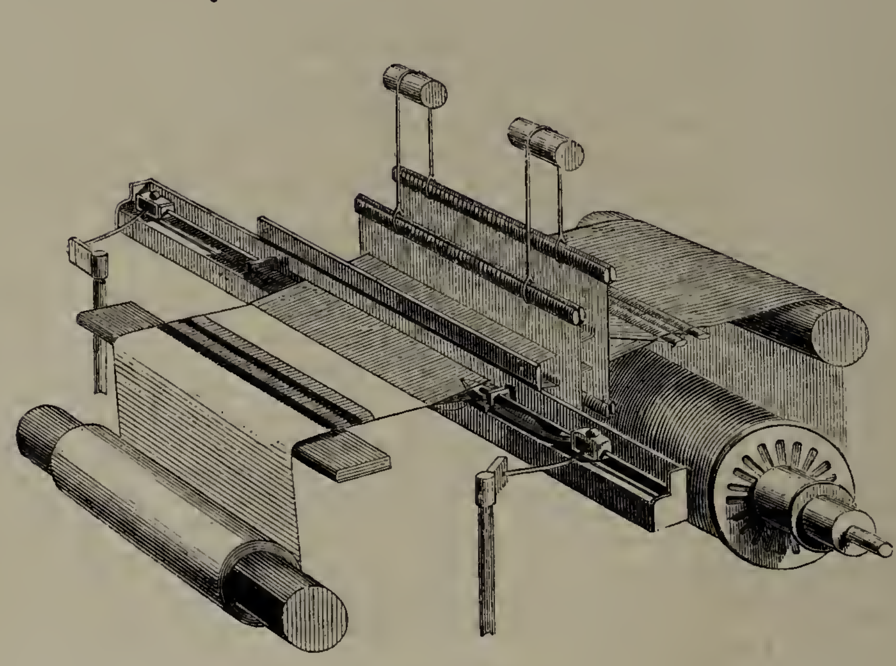
Now such apparatus, when fixed to various pieces of frame-work, and placed in connection with the moving power from a steam-engine, form the power-looms which give such a busy appearance to Figs. 512 and 513. These represent two of the vast weaving-galleries which are now so numerous in the manufacturing districts. In the gallery, or room, sketched in Fig. 512, there are no less than twelve hundred of these power-looms, all employed in weaving cotton goods; while in that represented in Fig. 513 there are eight hundred and fifty looms employed in weaving stuff or worsted goods, such as camlets, merinos, &c. The noise created by so many machines working near each other is so great as to be at first almost unbearable. The steam-engine sets the whole vast assemblage to work, and effects a number of different movements in each machine. It unwinds the warp from the warp-beam, raises and depresses the treddles, throws the shuttle, drives up the weft-thread after each throw, and winds the woven cloth upon the cloth-beam. In the cotton manufacture each loom is between three and four feet high by perhaps five or six wide, and the looms are so placed that one female can attend to two of them. The duties which these females have to fulfil consist in mending the warp-threads when they happen to break, replacing the empty shuttles by filled ones, replacing the warp-beam when emptied by another containing a new supply of warp, and removing the cloth-beam as fast as it is filled. The power-looms, Fig. 513, connected with worsted-weaving, are more complex, being provided with the Jacquard apparatus, of which we shall presently have to speak.

The most remarkable circumstance, perhaps, connected with the rise of the power-loom is the growth of new villages and towns which accompanied it. There is a spot on the banks of the Mersey, where Lancashire, Yorkshire, and Cheshire all meet, now occupied by some of the largest weaving and spinning factories in the empire, but which, thirty years ago, was almost entirely open country. The settlement of power-loom weaving at this spot arose out of the obstacles raised by the operatives to its introduction elsewhere. "The power-loom," says Dr. Taylor, "driven from West Houghton, sought shelter in a secluded nook adjoining to three counties, where there was neither church, magistrate, nor school. Here this branch of industry found a re-

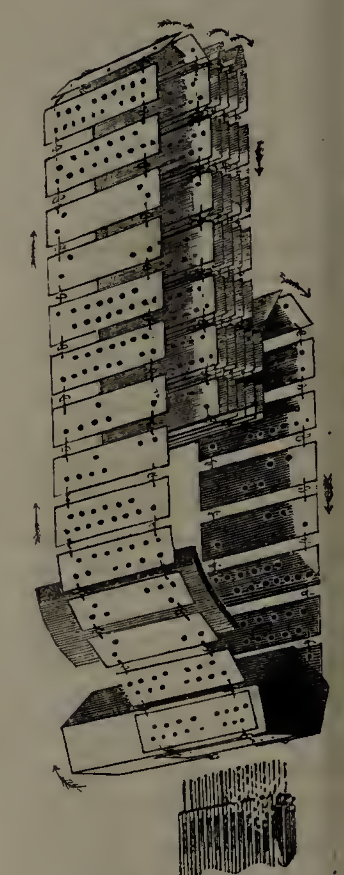
515.—Jacquard-card making.

513.—Jacquard Power-looms: Stuff-manufacture.

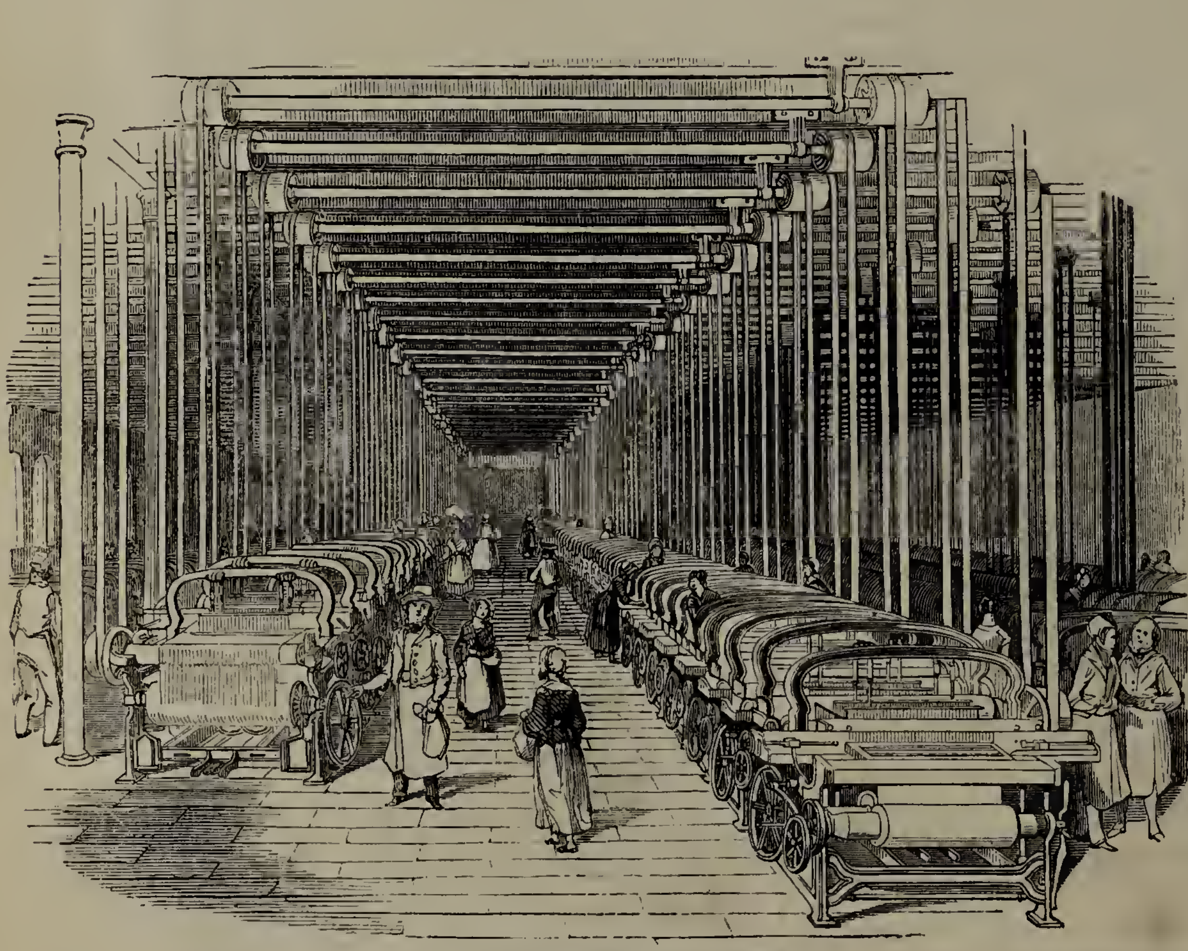
510.—Dr. Cartwright, inventor of the Power-loom.



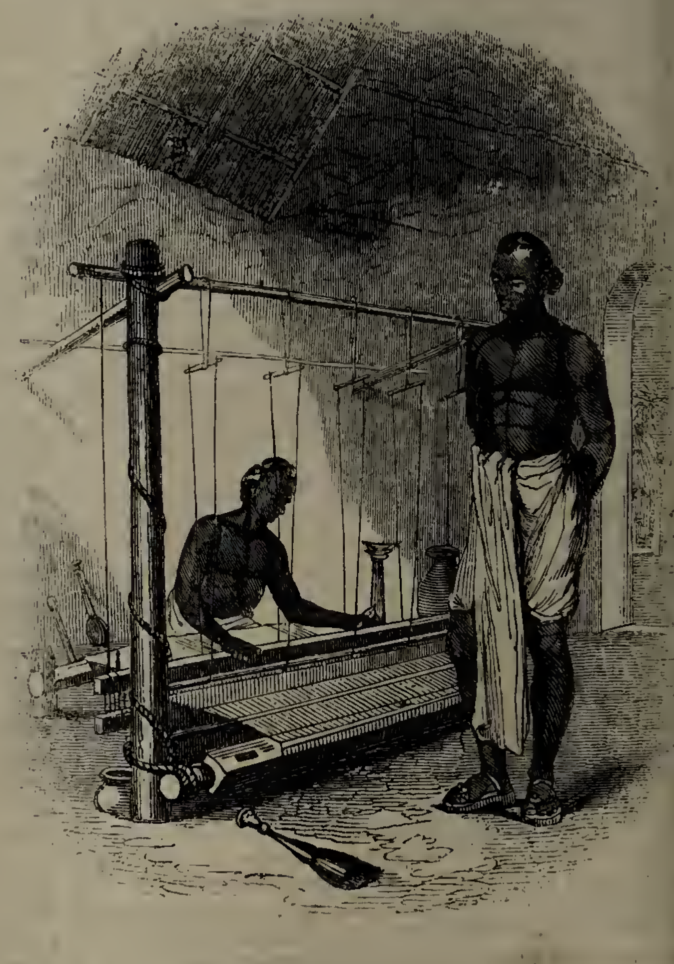
511.—Mechanism of Power-loom.



514.—Jacquard Apparatus.



512.—Power-looms: Cotton manufacture.



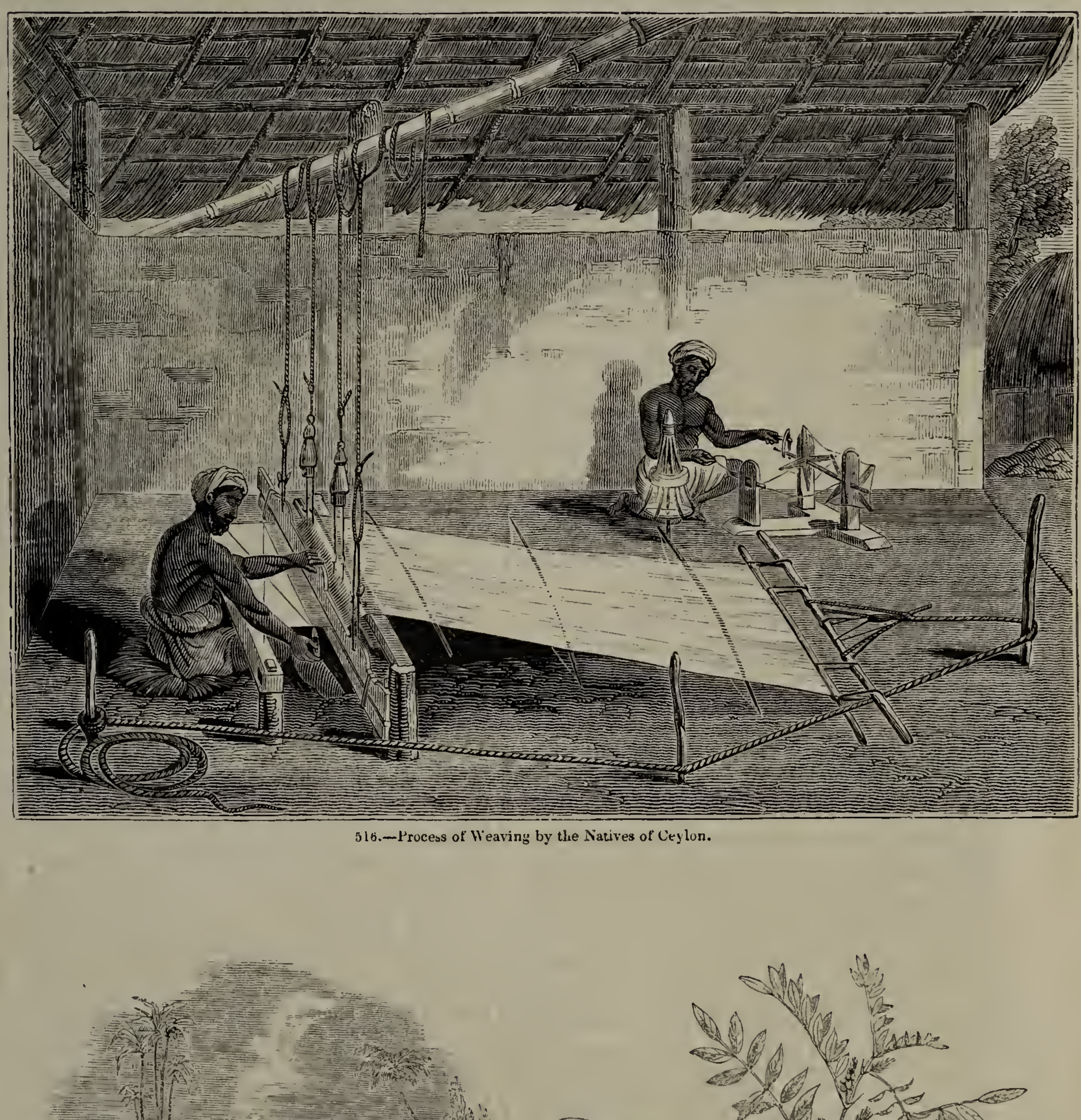
509*.—Hindoo Weaver at Work in a Shed.

517.—Madder: used for dyeing red.

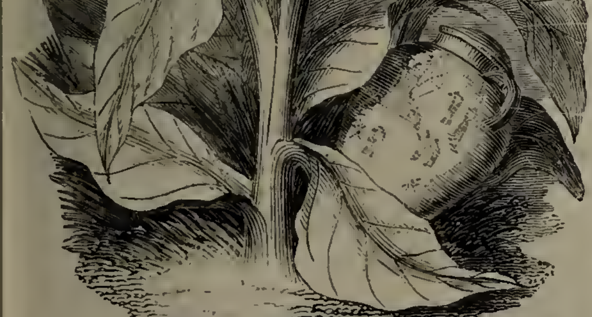
518.—Weld: used for dyeing yellow.

519.—Brazil-wood; used for dyeing red.

520.—Woad; used for dyeing blue.



516.—Process of Weaving by the Natives of Ceylon.



521.—Turmeric; used for dyeing yellow.

522.—Indigo-harvest in West Indies.

523.—Indigo; botanical features.

fuge and took root; Stayley Bridge, which seems to have been chosen by the patrons of the power-loom simply because it was neglected and deemed worthless by everybody else, is one of the most remarkable instances of the rapid accumulation of wealth, population, and buildings produced by the cotton manufacture, even in that land of wonders over which this branch of industry has spread. Some years ago it was a miserable hamlet, remarkable only for the picturesque views from the Old Bank, a steep hill which rises boldly above the north bank of the river, and, before the prospect was shut out by buildings, commanded an extensive view of very rich scenes. The cottagers, in addition to their agricultural pursuits, employed themselves in spinning woollen yarn for the manufacture of stockings. There was only one dyer in the place, and he possessed the solitary piece of workmanship which could be said to make any approach to machinery, which consisted of two wheels turned by mastiffs, similar to the dog-wheels anciently used in kitchens. It is now a flourishing town, with municipal institutions of its own, and extends to some distance on the Cheshire side of the river. The persons employed in the mills and factories have come at different times from the agricultural counties and districts; they are, in fact, colonists, not connected with Lancashire by birth or relationship, and are therefore very slightly influenced by local attachments." Stayley Bridge, Dukinfield, and Hyde are the chief manufacturing towns in the remarkable spot here spoken of.

The Jacquard Machine, and Fancy Weaving.

Up to the present point the weaving alluded to, whether conducted by hand or by steam-power, has been considered only as a mere interlacing of the warp and weft threads, without relation to the particular mode in which this interlacement is arranged. But it will be necessary next to speak of the production of *patterns* by the loom.

There are two classes of patterns capable of being produced in weaving; the one with uniformity of colour, and the other with diversity of colour. The former is illustrated by damasks, diapers, and similar goods, made of all the four fibrous materials: there is here observable a pattern of squares, lines, sprigs, diamonds, scrolls, &c. The latter is illustrated by woven goods too varied in kind to need particularizing: if the thread of the warp and the weft be differently coloured, and especially if there be many different colours both in the warp and the weft, a definite arrangement of these will, of course, produce patterns. In all such goods as damask, where pattern is produced without diversity of colour, a careful examination will show that the pattern results from the mode in which the weft-threads are made to cross over or under the warp-threads—in some places crossing over three or four at a time, in others one at a time, in others passing under three or four threads at once, and so on. Even where the threads are variously coloured, the production of anything like a graceful design depends quite as much on the manner in which the threads are made to intersect each other, as on the harmony of the colours.

This kind of ornamental or fancy weaving, then, depending on the mode of interlacement, it is evident that the arrangement of the loom, in respect to the manner of raising and depressing the warp-threads, is the main point to be regarded. In plain weaving, as we have before explained, the warp-threads are divided into two groups, ranged alternately throughout the width of the web or cloth; the one group being raised when the other is depressed, and *vice versâ*. But in fancy-weaving this uniformity of grouping is utterly departed from. In one "shoot" or transit of weft-thread it may possibly pass over ten times as many warp-threads as it passes under; the next time the relation may be exactly reversed; the third time the two groups may be equal in quantity; on some occasions the threads which it passes over may be very nearly all near one edge of the cloth, while in others they may be pretty equally spread over the whole width. All these matters depend solely on the patterns to be produced.

Now, these diversities depend on the manner in which the threads of the "heddles" take up the warp-threads. In plain weaving there are only two heddles, each of which is connected with exactly half of the warp; but in fancy weaving the heddles are more numerous, and each one takes up a quantity of the warp, depending entirely on the pattern to be produced. The threading of the warp-threads upon the heddle-strings, or the "drawing in," as it is called, becomes thus an intricate operation, and occupies a long time. So long as a simple pattern only is required, the arrangement of the heddles is practicable; but for a complex pattern the heddles would be too numerous for the loom to contain, or for the weaver to manage, and another contrivance is therefore adopted. We may take, as three examples of simple pattern, the varieties known as *shots*, *stripes*, and *checks*. A shot-pattern is one in which all the warp-threads are of one colour, and all the weft of another; but the weaving arrangements scarcely differ at all from those in plain goods. A stripe-pattern is one in which there are parallel lines running either along or across the piece of cloth, the stripes being alternately of different colours; if the stripes extend lengthwise of the cloth, the warper introduces different colours into his warp-thread, but the weaver proceeds nearly as for plain goods; but if the stripes be breadthwise, the warper provides only one colour, whereas the weaver uses shuttles containing threads of different colours. A check-pattern combines both forms of stripe, and requires different colours in the warp, and also different in the weft; so that both the warper and weaver have something more to attend to than in plain goods.

When the pattern becomes so complicated as to include flowers, scrolls, &c., some contrivance is necessary to avoid the too great multiplication of treadles in the loom. The *draw-loom*, the *draw-boy*, and the *Jacquard machine*, are three pieces of apparatus contrived at different times for this purpose. In the draw-loom there is an immense number of strings hanging down vertically, with weights or leads at their lower end; and a boy, by pulling these, weights, brings the various warp threads into such a position as to receive the weft in accordance with the pattern. All the warp-threads which are to be raised at once are connected with one handle, which the attendant boy pulls at the proper time. The enormous number of strings forming the "harness" of this kind of loom gives it a very complex appearance; and if the boy makes a mistake, by pulling the wrong handle, the weaver's weft-thread becomes wrongly thrown; to obviate this mischief a separate piece of apparatus was contrived, called the draw-boy, and it was to take the office which the boy had before filled. In this machine the weaver's foot pressed upon a treadle which, by giving a vibratory motion to a lever, drew down some of the warp-threads and elevated the rest.

But the Jacquard machine is the one which has become permanently established, and which is, year by year, more extensively employed. The history of the invention is a remarkable one, and was given a few years ago, by Dr. Bowring, to a Committee of the House of Commons on the silk-trade, as detailed to him by the inventor himself.

M. Jacquard was originally a straw-hat manufacturer at Lyons; and it was not until the peace of Amiens that his attention was first attracted to the subject of mechanism. The communication between England and France being then open, an English newspaper fell into his hands, in which he met with a paragraph, stating that a premium would be awarded by a society in this country to any person who should weave a net by machinery. The perusal of this offer awakened his latent mechanical power, and induced him to turn his thoughts to the discovery of the required contrivance. He succeeded, and produced a net woven by machinery of his own invention. It seems, however, that the pleasure of success was the only reward which he coveted, for as soon as accomplished he became indifferent to the work of his ingenuity: he threw it aside for some time, and subsequently gave it to a friend as a matter in which he no longer took any interest. The net was by some means at length exhibited to some persons in authority, and by them sent to Paris. After the lapse of a period, during which Jacquard almost entirely forgot his piece of mechanism, he was sent for by the prefect of Lyons, who asked him if he had not directed his attention to the making of nets by machines. The prefect rather peremptorily desired him to produce the machine by which this result had been effected. M. Jacquard asked three weeks for its completion; at the end of which time he brought his invention to the prefect, and directing him to strike some part of the machine with his foot, a knot was added to the net. The ingenious contrivance was sent to Paris, and an order was thence despatched for the *arrest* of the inventor.

It may seem strange that such a reward should be given for ingenuity; but under Bonaparte's government a very despotic way was often adopted of doing that which was, perhaps, well intentioned in the end. Jacquard found himself in the hands of the gendarmes, who conducted him to Paris so quickly that he had not time to provide any requisites for his journey. When at Paris, he was required to produce his machine at the Conservatory of Arts, and submit it to the examination of inspectors. After this ordeal he was introduced to Bonaparte and Carnot, the latter of whom said to him, with a look of incredulity, "Are you the man who pretends to this impossibility; who professes to tie a knot in a stretched string?" In answer to this inquiry the machine was produced, and its operation exhibited and explained.

When Jacquard had thus acquired a reputation for mechanical skill, he was required to examine a loom, on which twenty or thirty thousand francs had been expended, and which was employed in the production of articles for the use of Bonaparte. M. Jacquard offered to effect the same object by a simple machine, instead of the complicated one by which the work was sought to be performed; and improving on a model by Vaucanson, he produced the piece of apparatus which has since obtained the name of the Jacquard machine. A pension of a thousand crowns was granted to him by the government, as a reward for his discoveries; and he returned to Lyons, his native town. So violent, however, was the opposition made to the introduction of his loom, and so great was the enmity he excited in consequence of his invention, that three times he with the greatest difficulty escaped with his life. The "Conseil des Prud'hommes," who are appointed to watch over the interests of the Lyonese trade, so completely entered into the narrow feeling which prompted this opposition, that they broke up his machine in the public place or square. Jacquard says, that "the iron was sold for iron, the wood for wood, and he, its inventor, was delivered over to universal ignominy." The invention was, however, not lost: the Jacquard machine was constructed elsewhere, and gradually made its way in England and in France, wherever complicated fancy-weaving was to be executed.

The Jacquard apparatus is affixed over a loom, for the purpose of drawing up the warp-threads to form a "shed," into which the weft-thread may be thrown. There is a hollow box, on each of whose sides a great number of holes are pierced. There are also, for each pattern to be woven, a great many oblong cards prepared, the same size as the side of the box, and these cards are perforated in the same way as the box. There are as many cards as there are weft-threads to form one series of the pattern; sometimes amounting to twelve or fifteen hundred. The perforations in the cards, where they occur, correspond in position with some of those in the box; but the number varies greatly, being always less than that of the holes in the box. All the cards are linked together by joints, in such a manner that as the box rotates on a horizontal axis, the cards in succession lie flat in the several faces of the box.

The mode in which these perforated cards aid the object in view, is somewhat difficult to explain; but it may be stated thus:—If each face of the box has, say fifty perforations, then there are fifty small bars, or needles, ranged in a group, in exactly the same order as the holes in the faces of the box, the ends of the bars being immediately opposite the holes. Each bar is a lever, by which certain warp-threads are governed in such a way, that when the bars are moved longitudinally the warp-threads become elevated or depressed. The box is so connected with other mechanism as to have a movement to and from the ends of the bars in such a manner, that when one of its faces strikes against these ends, the latter will pass into the holes in the box if the face be not covered with a card; but if it be covered, some of the bars will pass through the holes in the card into the holes of the box; while others, at the unperforated parts of the card, will be driven aside. Thus, the bars become unequally acted on, and they in their turn act unequally on the warp threads, depressing some and raising others.

The cards are so perforated as to lead to the production of a pattern from this inequality of action; and the preparation of the cards thus becomes an important preliminary operation. In Fig. 514 we see so much of a Jacquard apparatus as relates to the cards, hinged together at their edges, and passing over a five-sided box at the top: while above them are shown the ends of the rods or bars which are to be acted on by them. In Fig. 515 we see the mode of stamping the holes in the cards. There is an arrangement of apparatus almost as complex as the Jacquard machine itself, for determining the number and position of the holes to be stamped in each card in accordance with the pattern; and these positions once ascertained, the holes are stamped at a press, and the cards are hinged together.

In the weaving-gallery shown in Fig. 513, the looms on the right hand are surmounted with the "draw-boy" apparatus, while those on the left have the "Jacquard" apparatus. Every kind of material is gradually coming within the range of this beautiful piece of mechanism, and its value to the art generally is incalculable. In reference to the striking power of this machine Mr. Porter remarks:—"The elaborate specimens of brocade which used to be brought forward as evidence of skilfulness on the part of the Spitalfields weavers of former days, were produced by only the most skilful among the craft, who bestowed upon their performances the most painful amount of labour: the most beautiful products of the loom in the present day are, however, accomplished by men possessing only the ordinary rate of skill, while the labour attendant upon the actual weaving is but little more than that demanded for making the plainest goods."

Velvet and Fustian Weaving.

There is a curious texture belonging to velvet, fustian, and a few other kinds of woven goods, showing that there must be some peculiarities in the process of weaving. This texture consists of a soft downy "pile," or "nap," standing up from the surface of the threads themselves, and in most cases quite hiding the threads themselves from view.

In making woven materials of this kind, instead of having only one row of warp-threads, as in common weaving, there are two rows or layers, one above another, and totally distinct. One of these, constituting the pile-threads, is introduced solely for the purpose of producing the pile or nap; whereas the other is the regular warp-thread requisite for the weaving process. If the pile-threads were worked in among the weft, in the same way as the warp-threads, the texture would

be simply that of a kind of double silk, but without any pile; the pile-threads are therefore formed into a row of loops, standing up from the surface of the silk; and by cutting these loops with a knife or sharp instrument the pile is produced. The weaver, therefore, has to perform his work so as to leave these raised loops, and this he does in a singular way. After the shuttle has been thrown three times across the web, making the weft interlace three times among the threads of the warp, he inserts a thin straight brass wire at right angles to the length of the cloth, or in the same direction as the weft; the wire being so placed as to occupy a position above the warp-threads, but below the pile-threads. The treadle is then worked, the warp-threads are changed in position, and another row of weft shot; the weft passing over the pile threads and half of the warp-threads, and under the remaining warp-threads; by which the wire becomes interwoven or confined among the threads. Two more transverses of weft are made, in the usual way of common weaving, but not interfering with the pile-threads. Another brass wire is then introduced, and entangled among the various threads as before; but always observing that the only threads *above* the wire are the pile-threads.

Then ensues the process by which at once the wire is liberated and the pile of the velvet formed; a process singularly exemplifying the delicacy of hand acquired by those accustomed to the work. Each wire is of a half-round form, or nearly so, and has along its upper surface a fine groove. The weaver passes the cutting edge of a sharp instrument, called a "trevat," quickly along the groove, so as to sever all the loops of pile-thread passing over the wire. The wire is liberated by this means, and is again woven in among the threads as a means of producing new loops. There is always one wire remaining in the piece, and this wire is not extricated until another one has been introduced. This operation is very surprising, since there are forty or fifty of these cuts made to every inch of cloth, and if the knife were to slip at any one of them, it might do irreparable injury to the piece. The complication of the proceedings, too, is very great, for the weaver has to manage two shuttles, the wires, and the cutting "trevat." "The use of the trevat in cutting the pile," says Mr. Porter, "calls for a certain amount of skilfulness or sleight of hand, only to be fully acquired through care and after long practice, while the minutest deviation from the proper line in performing this part of the process would infallibly injure, if it did not destroy, the goods; and the movements to be made throughout the entire operation are so numerous and require such constant changing of the hand from one action to another, that the weaver is greatly and unavoidably retarded in his process. It is considered to amount to a very good day's work when as much as one yard of plain velvet has been woven. For this the workman is usually paid five times the price charged for weaving Gros de Naples."

The length, fulness, and softness of velvet can all be regulated by the relative quantities of the three sorts of thread—warp, pile, or weft—introduced; sometimes striped velvet is made by leaving some of the loops uncut, while the others are cut in the usual way. Cotton is often, at the present day, made into a cheap and very inferior kind of velvet. *Fustian, velveteen, moleskin, beaverteen, cantoon*, and *corduroy*, are six different kinds of strong cotton goods, having more or less degree of pile at the surface, and made in a manner bearing a good deal of resemblance to that of silk velvet. In cutting the loops of fustian, the cloth is spread out flat upon a long table; and the workman, taking a peculiarly shaped knife, and inserting the projecting point under the loose pile-threads, runs the knife quickly along through a length of five or six feet, severing the pile-threads as he goes. The shape of the knife so employed is shown in Fig. 502. A machine has, however, been introduced for effecting this operation more quickly.

BLEACHING, DYEING, AND CALICO PRINTING.

Thus, then, we find that weaving presents many curious varieties of results; according as the hand-loom or the power-loom is employed; according as the woven material is to be plain, or is to be twilled, or striped, or checked; according as it is more or less ornamental, and the ornaments produced by the draw-loom, the draw-boy, or the Jacquard-loom; according as the woven threads are left visible, or are hidden by a velvet-like pile or nap; according as the threads are all of one colour, or are of two or more colours succeeding each other in pre-arranged order. These matters being glanced at, we are now ready to consider those extensive and beautiful arts, the object of which is to impart a pure whiteness, or a brilliant colour, or a painted or printed pattern, to the surface of woven cloth.

These arts differ essentially from those of spinning and weaving, as being much rather of a chemical than of a mechanical character. The mutual action of colours and of textile fibres, the action of colour upon colour, the permanence of the colour produced, the power of removing all colour, and obtaining a snowy whiteness of surface, the state in which the colours can be best applied; the fitness of the material for the particular mode adopted—all belong very closely indeed to the domain of chemistry. Indeed, so much is this the case, that the chemical managers of the great Lancashire print-works are among the best practical chemists of the day, especially in relation to the chemistry of colours.

There are three distinct stages in this series, having three objects in view. The first is the *bleaching* of those goods which are to remain white, and which are never quite white when they leave the loom; the second is the *dyeing* of a piece of cloth uniformly of one colour; and the third is the *printing* of a device on the cloth, by means of variously coloured pigments, applied in a way bearing a tolerably close resemblance to other kinds of printing.

Before treating of the processes themselves, it may be well to glance at a few of the

Plants used in Dyeing.

By far the greater number of the colours imparted to woven goods are derived from plants, which are gathered for that purpose, and subjected to a train of processes for the separation of the colouring matter from the other parts of the plant. Sometimes the leaves, sometimes the seed, at others the root, at others the flower, affords the desired product.

Among the plants yielding a red dye is *Madder* (Fig. 517), the colouring substance being obtained from the root. The plant grows in most of the southern countries of Europe, but has not been successfully cultivated in England. The root is perennial, having an annual stalk, and is composed of many long thick succulent fibres, about a quarter of an inch in thickness; many lateral roots issue from the upper part or head of the parent root, and extend just beneath the surface of the ground to a considerable distance. The plant does not bear flowers until the second or third year, when it blows in June, and the flowers are succeeded by berries which contain the seeds. At the latter end of September, when the leaves have fallen off, the roots are taken up and dried for the market, in a place covered overhead, but open to the air on all sides. At the expiration of four or five days, during which time they are turned over, the roots are conveyed to kilns constructed for the purpose, where they are still further dried. They are next placed on a clean floor, and threshed with a flail to remove the dirt and the thin outer skin. The skin is used for the preparation of a very inferior kind of colour; but the remaining part of the root is again dried in a kiln, to remove every semblance of moisture, and is next conveyed to a pounding-house to be ground to fragments. The roots are ground either between millstones or by a peculiar kind of knife-mill; after which the impurities are separated by means of boulters or fanners. Three times successively the root is ground, in order to cleanse it as much as possible from any skin or husk. When quite prepared, the powdered root is packed carefully in large barrels, and in that state sold to the dyers. The madder prepared by the Dutch, which has a yellowish tinge, is used principally by the woollen dyers: whereas the French madder, rather redder in tint, is preferred by the cotton dyers. When required for use, the powdered root yields up its colouring matter by steeping and boiling in water.

Weld (Fig. 518), sometimes called "dyer's weed," produces a fine yellow colour, very much employed by dyers. The leaf and stem yield the colouring matter. The stem rises to a height of from one to three feet. The seed for the young plants is sown in April or May, generally on the broadcast method. Being a biennial, and no advantage being obtained from it the first year, it is sometimes sown with corn-crops in the manner of clover; but the best crops are obtained by cultivating the weld alone. It is usual to thin the plants to a mutual distance of six or eight inches. The crop is taken by pulling up the whole plant; the proper period being when the bloom is just produced along the whole length of the stem, and the plants are just beginning to assume a light or yellowish colour. The plants are drawn up by the roots in small handfuls; and after each handful has been tied up with one of the stalks, they are set upright in small groups, and left to dry. After they have remained till fully dry, which takes place in a week or two, they are bound up into large bundles, each containing sixty handfuls, and weighing about as many pounds: sixty of these bundles make a load. The peculiarity of this dye-material is that the whole plant is used by the dyer to produce the yellow decoction which serves him as a dye. There seems to have been no sufficient investigation as to the real seat of the colouring matter in the plant; for while some consider it to lie in the leaf and stem, others seek for it only in the seeds; while others, deeming the entire plant to be valuable, employ the whole of it in making the decoction. The decoction yields various shades of yellow, from a brownish to a greenish tinge. Blue cloth is dipped in it to convert the colour to green.

Brazil-wood (Fig. 519), which yields a useful red dye, is the wood of several kinds of tree growing in Brazil called *Cæsalpina*. The wood is very hard, sinks in water, is sweetish to the taste, and rich in colouring matter, which is pale when the wood is first cut, but becomes redder by exposure to the air. The Portuguese, when they gained possession of Brazil, soon found out the value of this production; and it was made one of the objects of royal monopoly, being imported into Europe as a source of crown-revenue; from this circumstance it is known in Brazil as "Pao da Rainha," or Queen's wood. The bark of the tree, as also the white pithy part, are both useless, the only valuable portion being the heart-wood. The wood is sometimes used in turnery, and is susceptible of a good polish; but its principal use is as a red dye. When boiled in water for some time, the wood furnishes a fine red decoction, and a further portion of red may be extracted from the residue by the application of alkalies. The decoction is generally combined with some other colouring matter, so as to give various shades of orange and red. There are two circumstances, however, which bid fair to lessen the use of this dye-material: one is, that the cultivation is declining in Brazil, on account of the improvident way in which the trees are cut down by the government agents, and also of many planters having privately destroyed the trees on their estates, that they might not expose themselves to the arbitrary and vexatious proceedings of those agents; the other is, that the wood of the tree called *camwood*, brought from Africa within the last few years, is found to yield a red dye larger in quantity and finer in quality than the Brazil-wood.

Woad (Fig. 520) is a plant which was known to our British ancestors, for they employed it to procure a blue dye for staining the skin. The dye-material of the woad-plant resides in the leaves. The plant, which is cultivated both in England and on the Continent, is a biennial, with a strong thick fibrous root and yellow flowers. The plant is sown in spring, and there are three or four crops of leaves obtained in a year, at intervals of about six weeks apart. From these leaves the dye is obtained in the following manner:—As soon as the leaves are gathered, they are taken to a mill and ground into paste, which is laid in heaps, and pressed close and smooth. A blackish crust forms on the outside, which is kept free from cracks, as the quality of the plant is thereby better preserved. After lying for about a fortnight, the heaps are opened, the crust rubbed and mixed with the interior portion, and the whole formed into oval balls, which are pressed closely in wooden moulds. These are dried upon hurdles, and they acquire a difference of external appearance according to the degree of exposure to sun and air. These balls of leaves have an agreeable smell, and appear of a violet colour when rubbed. For the use of the dyer they require a further preparation. They are beaten with wooden mallets, on a brick or stone floor, into a coarse powder, which is heaped up in the middle of the room to a height of three or four feet. The powder, moistened with water, ferments, and is allowed to remain in this state for a fortnight, being turned repeatedly during the time. The leaves lose a good deal of their organic quality by this fermentation, and the powder is then ready to be used by the dyer. It at first yields only a brownish dye; but by a particular mode of treatment, it imparts to cloth a green colour, which is changed to blue by the action of the atmosphere.

Turmeric is the prepared root of an Asiatic plant called the *Curcuma longa* (Fig. 521). The roots, which spread far under the surface of the ground, are long and succulent, and about half an inch in thickness, having many circular knots, from which arise four or five spear-shaped leaves, standing upon long footstalks. The roots are externally of a colour inclining to grey, but internally of a deep yellow: they are very hard, and bear a good deal of resemblance to ginger both in figure and size: it has a slightly aromatic and not very agreeable smell, and a bitterish and acrid taste. It readily gives out its colouring ingredient both to water and to alcohol, communicating to the former a deep yellow, and to the latter a fine yellowish red tint. The roots are reduced to powder previously to being employed as a dye. The yellow produced by turmeric is very beautiful and rich; but it is deficient in permanence; and this circumstance has led to the extensive substitution of other plants instead of it.

Indigo (Figs. 522, 523) is one of the most notable of the dye-plants, both from the value of the dye itself and from the history of its use. For a long series of years after indigo was imported from India into Europe as a dye-material, the purchasers were ignorant of its nature; some deeming it to be a mineral, some a plant. Its introduction into general use was violently opposed for several years, since it lessened the consumption of woad, which had till then been the common blue dye in Europe; but it gradually came into extensive use, and the mode of preparing it in India became known. The leaves of an Asiatic plant, the *Indigofera anil*, yield the indigo of commerce. The plant is ripe in two months after being sown: when it begins to flower it is cut with pruning-knives; and again at the end of every six weeks. When the leaves are gathered, they are thrown into a large vessel filled with water, care being taken not to scatter a kind of bloom or down which is found on the leaves, and which constitutes a consider-

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527.—Washerwomen on the Seine, Paris.

524.—Logwood Tree ; used for dyeing.

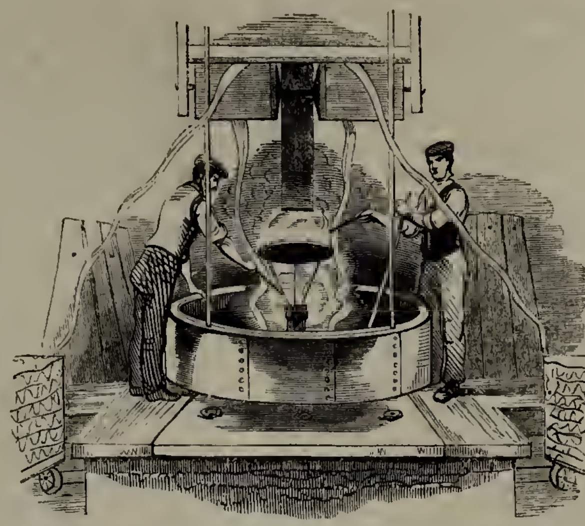
526.—Orchil : used for dyeing violet.

525.—Arnatto ; used for dyeing yellow.

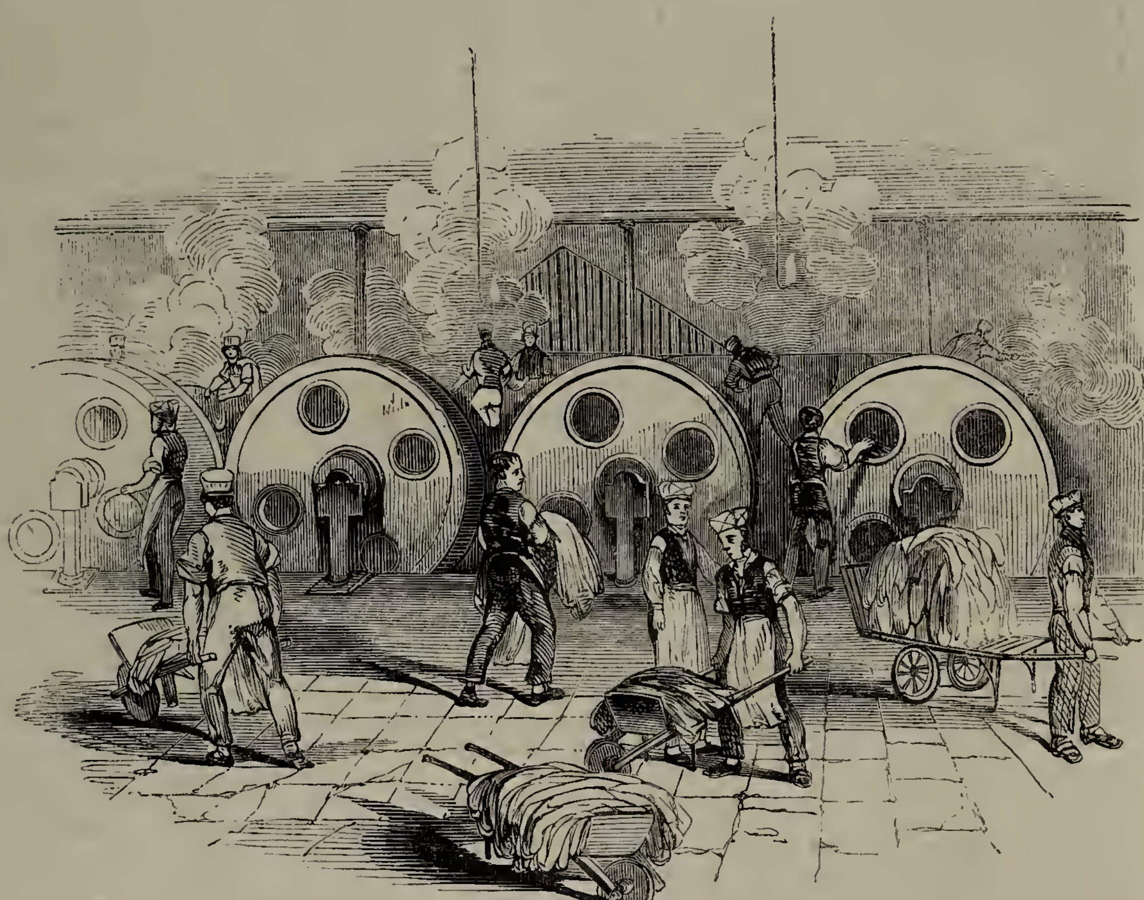
528.—Bleaching-ground at Glasgow.

529.—Singeing Calico, before bleaching.

530.—Public Washing and Bleaching Grounds, 1582. (From Harleian MS.)



532.—Boiler, for bleaching Cotton.



533.—Wash-wheels, for dyeing and bleaching.

534.—Calico-printing by Cylinder.

531.—Egyptian Women washing and bleaching at the river.

able part of their value. When the leaves have fermented, the water is drawn off into a second vessel, and the liquid is found to be impregnated with an earthy substance, which alone forms the blue substance known as indigo. A variety of processes then ensue to separate this earth from other substances with which it is combined; and when these are completed, the indigo, as a kind of paste, is packed in chests, where it dries gradually for the market.

Indigo is one of the most precarious of all vegetable cultures. The sources of disaster are so numerous, that there is a saying in India to the effect that very frequently "an indigo-planter goes to bed rich, and rises in the morning totally ruined." Mr. Edwards thus speaks of the indigo speculations of the West Indies:—"Unhappily, however, the golden hopes which speculations like these have raised in the minds of thousands have vanished on actual experiment like visions of the morning. I think I have myself, in the course of eighteen years in the West Indies, known at least twenty persons commence indigo-planters, not one of whom has left a trace by which I can now point out where his plantation was situated, except perhaps the remains of a ruined cistern covered by weeds and defiled by reptiles. Many of them, too, were men of knowledge, foresight, and property. That they failed is certain, but of the causes of their failure I confess I can give no satisfactory account. I was told that disappointment trod close at their heels at every step. At one time the fermentation was too long continued; at another the liquor was drawn off too soon; now the pulp was not duly granulated, and now it was worked too much. To these inconveniences, for which practice would doubtless have found a remedy, were added others of much greater magnitude—the mortality of the negroes from the vapour of the fermented liquor, the failure of the seasons, and the ravages of the rain. These or some of these evils drove them at length to other pursuits where industry might find a surer recompense."

The use of indigo as a dye is attended with some peculiar circumstances. In its real state as indigo it is insoluble in water, and only becomes soluble when it is so chemically changed as to produce a *yellow* dye, and to combine with lime or potash. But any woven fabric which has been thus dyed yellow begins to turn green immediately on exposure to the atmosphere, and the green gradually changes to the blue for which indigo is so much valued. Indigo will yield thirty times as much colouring matter as an equal weight of woad, and this too of superior quality; a circumstance which amply explains the spread of the use of this dye-material.

The *Logwood-tree* (Fig. 524) yields a dye very serviceable for many purposes. The tree, which grows in most of the West India Islands, produces wood which is hard, compact, dense, and of a deep red colour internally. It is brought to this country in logs about three feet in length; and these logs are reduced to fragments before being fitted for the use of the dyer: a reduction which is effected in one of three ways. The first of these consists in the use of a machine containing knives fixed to a large wheel: the knives chip the wood across the grain into small fragments, which are afterwards reduced to a fine powder by grinding them beneath a pair of rolling stones. A second method is by a machine provided with steel bars having a great number of teeth or notches at the edges: these rasp and cut the ends of the wood into powder. The third method is by means of a circular saw, which at every cut produces as much logwood sawdust as is equal to the thickness of the saw, and is at the same time so contrived as to shatter into fragments the thin slices of logwood.

Logwood-cutting was a speculative trade carried on by English adventurers in Campeachy a century or two ago; and Dampier gives a curious account of what he saw among them:—"The logwood-cutters inhabit the creeks of the east and west lagunes in small companies, building their huts by the creeks' sides for the benefit of the sea-breezes as near the logwood groves as they can, removing often to be near their business: yet when they are settled in a good open place, they choose to go half a mile in their canvas to work than lose this convenience. Though they build their huts but slightly, yet they take care to thatch them very well with palm or palmet leaves, to prevent the rains, which are there very violent, from soaking in. For their bedding they raise a barbecue or wooden frame three feet and a half above ground, on one side of the house, and stick up four stakes, at each corner one to fasten their curtains, out of which there is no sleeping for moskitoes. Another frame they raise covered with earth for a hearth to dress their victuals; and a third to sit at when they eat it. During the wet season, the land where the logwood grows is so overflowed that they step from their beds into the water, perhaps two feet deep, and continue standing in the wet all day till they go to bed again; but nevertheless account it the best season for doing a good day's labour in. Some fell the trees, others saw and cut them into convenient logs, and one chips off the top, and he is commonly the principal man; and when a tree is so thick that after it is logged it remains still too great a burden for one man, they blow it up with gunpowder. The logwood-cutters are generally sturdy, strong fellows, and will carry burthens of three or four hundred weight; but every man is left to his choice to carry what he pleaseth, and commonly they agree very well about it; for they are contented to labour very hard. In some places, especially in west creek of west lagune, they go a hunting wild cattle every Saturday to provide themselves with beef for the week following. When they have killed a beef, they cut it into quarters, and taking out the bones, each man makes a hole in the middle of his quarter, just big enough for his head to go through, then puts it on like a frock and trudgeth home; and if he chanceth to tire, he cuts off some of it and throws it away."—There is something very rich in this idea of making a frock out of a quarter of "a beef."

In using logwood as a dye, the raspings may be easily made to yield their colouring matter by boiling in water; and this colour is employed either to impart a reddish dye, or to brighten the tints given by some other ingredients, or to effect the former as a preparative to the latter.

Arnotto, a substance obtained from a plant called *Bixa orellana* (Fig. 525), is employed to give a yellowish dye to cloth, and also to cheese. It is a kind of red paste obtained from the berries. In the seed-pod of the plant are contained thirty or forty seeds enveloped in a reddish pulp; and this pulp, with the contained seeds, is softened in water until the pulp separates from the seeds. The mass is strained and boiled: a scum rises to the surface; and this scum, when cooled and moulded into roundish lumps, constitutes arnotto. This material is employed by the dyers to impart a deep orange tint to silk and cotton: the dye is rich and brilliant, but not very permanent.

From a plant called *rocella tinctoria* (Fig. 526) is prepared a very beautiful violet dye called *orchil*, or archil, or orchella (the name being spelled in many different ways). The rocella is a white moss or lichen, growing upright, either in single or double stems of about ten inches in height: these are cylindrical, and internally white. It is imported as gathered, without receiving any previous preparation; the sources whence our importers obtain it being chiefly the Canary and Cape de Verde Islands and the Greek Archipelago. In obtaining the colouring agent from the plant, the mass is reduced to a fine powder, passed through a sieve, and mixed with soda and other ingredients: this mixture, after steeping and other processes, is made up into paste, which is afterwards dried and pounded.

Such are a few of the principal vegetable substances which yield colours for the dyer; and they will serve as examples of the whole. Almost every part of a plant, in some one or other of the instances, is applied in this way. Thus, some of the dye-ingredients are produced from the whole plant, as in the case of orchil, indigo, and woad; some from the wood, as Brazil-wood, sandal-wood, log-wood, cam-wood, and fustic; some from the root, such as madder and turmeric: some from the bark, such as quercitron and birch-bark; some from the flower, such as safflower: some from the shoots, as sumach; some from the leaf and stem, as weld; some from the berry, as arnotto and Persian berries; and some from the juices, as catechu and gall nuts.

The Bleaching of Cotton Goods.

Many varieties of woven goods, before being dyed by any of the ingredients above noticed, require to be bleached or whitened, both for their purity of appearance while in the white state, and from the brilliancy of the colours when printed or dyed.

The process of bleaching is connected with one of the most valuable chemical discoveries of late years, viz. the power of *chlorine* to remove almost all kinds of colour. Before that discovery was made, exposure on the clean grass of a field, after a thorough washing, was the chief known means of bleaching woven cloth. The river side was the place for washing, and the field adjoining was the place for drying and bleaching: the alternation of dew, fresh air, and sunshine, bringing about the bleaching operation by slow degrees. We may draw a comparison between various modes of carrying out some or all of these objects by glancing at Figs. 527, 528, 530, and 531: the first relates to Paris in the present day; the second to Glasgow at the present day; the third to a period two or three centuries ago, not connected with any particular country especially; and the fourth to an Oriental custom.

The first of these (Fig. 527), relating to the washing operations carried on in the Seine at Paris, does not apply immediately to the bleaching, but to the primitive mode of washing, which was closely connected with the former modes of bleaching. Paris is not supplied with water so plentifully as London; or, at least, whatever may be the mass of water supplied by its fountains and Artesian wells (as noticed in Chapter II.), the distribution to the houses is much less complete. The conveyance of water in pails requires either a great consumption of time or a too great expenditure of money, or both; and it has therefore been for many years a custom for the "*blanchisseuses*" or laundresses (whose designation, by the bye, is equivalent to that of "bleachers") to take their linen down to the river side, and there subject it to washing; in several large boats which are provided for them they carry on their operations in a manner much more economical than if they were to purchase water, or to convey it with great labour to their own apartments. The occupation of these women has been made the groundwork for a short tale in Messrs. Chambers's 'Miscellany of Useful and Entertaining Tracts' (No. 17). The writer, as an introduction to the tale itself, thus speaks of the barges and of the women employed in them:—"At boats of this kind, all the laundry washing of Paris is performed,—the clear water of the river, as it runs past, with a piece of soap, and a mallet to beat the clothes, being the sole means of purification. The labour is considerable, and the payment for it small; yet no women are more cheerful than these laundresses. Exposed at all seasons to perpetual damp, which saturates their garments, and prematurely stiffens their limbs, they still preserve their national vivacity, which finds vent in many a song; and in a spirit of cordial fellowship, sympathize with each other in prosperity and adversity. Earning on an average little more than two francs, or twenty pence, daily, they nevertheless agree to set aside rather more than twopence out of that sum towards a fund for unforeseen calamities, and, above all, to prevent any of their number, who may be laid aside by illness, from being induced to seek other relief. The greater part of them are married women with families."

The Egyptian scene, depicted in Fig. 531, exhibits similarly the custom of washing by the side of a river, as adopted in many Eastern countries. In Fig. 530 we have a copy from a curious drawing contained among the Harleian Manuscripts, and dated 1582. This seems to represent a public washing-ground, with a fire and the necessary apparatus out in the open air, and a series of lines and bleaching-fields on which to place the linen. This approaches more nearly to our immediate subject than the two cuts before spoken of; for there are evidently here long pieces of linen, stretched out at full length, and lying on a grassy sward to bleach. The drawing itself exhibits some rather questionable points as to perspective; but it is not without value as representing one of the usages of the times when it was drawn. The bleaching arrangements depicted in Fig. 528, of which we shall have to speak presently, so far resemble the above as to involve the spreading of the woven cloth on the clean grass of an open field.

The common mode of bleaching linen, for centuries before cotton was known in this country, was by exposure on a bleach-field. It was customary to send the linen manufactured here to Holland to be bleached; and the Dutch, when they received it, steeped the linen for several days in a solution of potash, then washed it; then steeped it for a week in buttermilk, and then spread it out upon the grass: there the linen remained for some months, exposed to all the alternations of air, sunshine and moisture, by which it became bleached. So much time was consumed by this method, that cloth sent over to Holland in the spring was not received back till autumn. Sometimes cloth was bleached at home; but the great space of ground which it occupied, and the liability to depredation which accompanied the exposure of the goods, rendered some other method more desirable, and induced chemists to seek for some mode of removing the yellowish tint from woven linen and cotton without lengthened exposure on the grass.

After several steps had been taken in this direction, it was discovered, about sixty years ago, that a gas called *chlorine* possessed this power; and hence experiments were made to determine the best mode of using this material. It was first used in the state of simple solution in water; but afterwards a very efficient mode was discovered of combining it with lime so as to form a dry powder, which powder, when dissolved in water, possesses the same bleaching power as the chlorine itself. The powder, called "bleaching-powder," or "chloride of lime," is certainly one of the most valuable gifts which chemistry has made to the arts.

The trade of bleaching gives employment to some of the very largest establishments in Lancashire and in the neighbourhood of Glasgow. Nearly all cotton and linen goods are bleached after being woven; and the immense quantity thus treated every week requires extensive arrangements on the part of the bleachers. The application of the liquid bleaching agent, though the most important stage in the processes, is by no means the only one.

In the first place, supposing cotton goods to be those which are to be bleached, the cotton is sent to the bleach-works in the "grey" state, that is, just as it leaves the loom. It is in bundles measuring about a foot in width and in depth, and as long as the width of the cloth. Cotton cloth is generally woven into detached lengths called "pieces," which vary from twenty-four to about forty-eight yards long each; the average being twenty-eight yards. These are not bleached as separate pieces; but women are employed to stitch ten of them together, end to end, so

as to produce one continuous piece two hundred and eighty yards long.

These long pieces are "singed" at the surface, before being wetted with any of the bleaching agents. There is employed for this purpose a curious kind of furnace (Fig. 529). There is a surface of copper, heated by gas flames beneath, so placed that the long strip of cotton may be drawn over it two or three times; the light hairy filaments are by this process singed off from the surface of the cotton, and the cotton then passes round a wet roller to cool after the effects of the heating. This being done, and the woven fibres being thereby rendered fit for the reception of the various liquids to which they are exposed, the bleaching commences, and involves a curious succession of processes, requiring the aid of chemical agents of different kinds.

The long pieces of singed cloth are still further connected by being sewn together at their ends, until at length they form one piece of cloth nearly *eight miles* long; and the immense piece retains its length throughout the bleaching processes. It is conveyed into a large washing-machine, to cleanse it from the paste or other "dressing" which had been introduced into the warp before weaving. The cloth hangs over a beam at a height above the washing vessel, and, descending into the water beneath, travels over the roller-beam repeatedly, so that every part of the cloth dips into the water twenty or thirty times. This done, the cloth is folded backwards and forwards until the whole bulk forms a cubical mass; from which it is again unfolded to undergo the process of *liming*. This consists in exposing it to the action of a hot solution of lime. There is a curious kind of boiler (Fig. 532), called a *keir*, which has a central pipe passing up into it: through this pipe hot water is driven up by steam-power; and there is a sort of concave reflector over it, which causes the water to be reflected downwards, thereby falling in a continuous shower on the cloth in the vessel. This operation continues eight or ten hours, the water being mixed with lime during its continuance.

Time after time does the cloth undergo steepings and boilings, to prepare it more and more for the reception of the real bleaching agent. After the liming it is exposed to a process termed *grey-souring*: this consists in steeping the cloth in water containing a little sulphuric acid. Next it is washed in the washing-machine, to remove any adherent acid; then boiled sixteen hours in a solution of soda; and then again washed. The bleaching process now takes place. Bleaching-powder, or chloride of lime, is dissolved in water, and the cloth is passed through this solution: after being allowed to remain wet several hours, for the bleaching agent to act on the fibres, the cloth is exposed to a second steeping in acidulated water; then another washing; then another boiling in a solution of soda; then washing again; and then another exposure to the action of the bleaching liquor. This repetition of processes goes on many times, and well illustrates the remarkable nature of this chemical branch of manufacture: the lime, the acid, and the soda all have to contribute in various ways to the end in view, subsidiary to the actual bleaching: while the water is requisite to remove the adherent matter from the fibres of the cloth.

After the cloth has become bleached, it is squeezed between rollers dipping into hot water; then ripped or separated into the original pieces, twenty-eight yards each, and hung up to dry on bars in a room heated by steam-pipes.

Such are the modes in which bleaching is effected in our own day; and this strikingly exemplifies the advantages which modern chemical research has conferred on this department of industry. This removal of colour is especially intended for such cotton goods as are not to be dyed or printed; but various goods of the latter kind also require the bleaching process to fit them for the reception of colour.

The Process of Dyeing.

Here, again, we have examples of the intimate connection between chemistry and manufactures. It is only by long series of chemical investigations that the fitness of any particular sort of textile fibres for the reception of dye materials can be determined. The dyeing of silk, of cotton, of wool, of linen, all have their peculiarities; each kind of fibre having a greater degree of affinity for one colouring substance than another.

That the art of dyeing was known and valued among early nations, is abundantly clear. The allusions to "purple and fine raiment," to "dyed garments," to "cloth of many colours," &c., are numerous in the Bible. In a note to the 'Pictorial Bible,' after an allusion to the antiquity of this art, and to the preeminence attached by the ancients to *purple* beyond every other colour, it is remarked:—"It is important to understand that the word purple, in ancient writings, does not denote one particular colour. Pliny mentions the difference between some of the purples: one was pink, approaching to a scarlet, and that was the least esteemed; another was a very dull red, approaching to a violet; and a third was a colour compared to coagulated bullock's blood. The most esteemed Tyrian purple seems to have been of the last colour; we say the most esteemed, because it appears that even the Tyrian purple was not one particular colour, but a class of animal dyes, as distinguished from vegetable, varying in shades of purple, from the most faint to the most intense. It is to be understood, however, that the Tyrian purples were more esteemed than any other colours, although they differed in degree of value. Of the vegetable purples we know nothing; most of the information relates to the purple of the Phœnicians: their dye was obtained from several varieties of shell-fish, comprehended under two species; one (Buccinum) found in cliffs, and the other (Purpura, or Pelagia), which was the proper purple-fish taken at sea. The first was found on the coasts of the Mediterranean and Atlantic, and locally differed in the tint and value of the dye which they furnished. The Atlantic shells afforded the darkest colour; those of the Italian and Sicilian coast, a violet or purple; and those of the Phœnician coast itself, so general on the southern coast of the Mediterranean, yielded scarlet colours."

There is a circumstance connected with dyeing which influences much the choice of materials. It is this: the solutions of the dye-material in water, though capable of penetrating between and among and into the fibres of the cloth, do not, in most cases, continue with them so strongly as to present "permanent" colours, unless aided by some third substance. This assistant, whatever it may be, is called a *mordant*, and has a mutual action both on the cloth and on the dye-material. The mordant serves as a bond to connect the other two; and in some cases it also modifies the tint of the dye itself. Hence the processes adopted by the dyer comprise mainly the exposure of the cloth to the action of the mordant, and then to the action of the dye-material.

In some of the great establishments of the north, the dye-houses are buildings of large dimensions, containing vessels of great capacity and in great number, and very complete arrangements for supplying steam, water, and heat for the various processes. The customary mode in these buildings of exposing the cloth to the action of a liquid, is not to immerse the cloth wholly in it, but to pass it over a roller above, and to allow it to dip continuously and repeatedly into a vessel containing the dye-material. If the attention, for example, were fixed upon any particular portion of the length of cloth, it would be seen that this portion, after dipping in the liquid passes upwards, thence over a roller, and thence down again into the liquid; thus having a certain degree of exposure to the open air after each immersion. Sometimes, too, in order to force the dye-material into the innermost pores of the cloth, by forcing out the air previously contained in them, the cloth is pressed between smooth wooden rollers after each immersion.

In dyeing, as well as in bleaching, the cloth requires repeated washings to cleanse it from adherent impurities. This is done in large revolving machines called "dash-wheels," or "wash-wheels" (Fig. 533), which act in the following manner:—The wheel, which is about six feet in diameter by two deep, is separated within into four compartments, to each of which there is an opening from within. Water gains admittance to the interior of the vessel, and cloth being put in at the openings, and the machines being made to revolve, the cloth becomes tossed about in the water, and thereby washed. Another kind of machine employed is a centrifugal drying-machine, consisting of one cylinder within another. The inner cylinder has perforations at its surface, and its capable of revolving a thousand times in a minute. The wet cloth is put into the inner cylinder, and if the cylinder be made to revolve, the centrifugal force thus generated will make the cloth press forcibly against the interior of the cylinder, and will cause the water to ooze out of it, and to pass through the holes into the vacant space between the two cylinders. The effect of this is so remarkable, that if a large mass of cloth, thoroughly saturated with water, be put into the machine, it is taken out a minute or two afterwards scarcely damp to the touch. Other machines contribute in various ways to the wetting, the dyeing, or the cleaning of the material, either in the state of woven cloth or that of yarn. In Fig. 536, for instance, there is seen a very simple mode of wringing out yarn after it has been dyed; and in Fig. 537, a mode of squeezing yarn between rollers, after dipping into any cleansing or dyeing liquid.

To show the order and mode in which the dyeing processes are carried on, one specimen will suffice, provided it belong to a rather elaborate class. Let us take, then, the "Turkey-red" dye, which is employed so largely for pocket-handkerchiefs. This "Turkey-red" dye has had a peculiar connection with the past history of dyeing. The production of this brilliant red appears to have been first known in India; from whence it passed to Western Asia, to Greece, and to Turkey. During the early half of the seventeenth century two French manufacturers went to Turkey, and induced two Greek dyers to come to France, and superintend the establishment of this kind of dyeing in that country. A long time elapsed before any attempt was made to introduce the Turkey-red mode of dyeing into Britain; but it was at length accomplished by slow degrees, after encountering many difficulties; and it has, for more than half a century, constituted one of the finest branches of mechanical, or rather chemical, art at Glasgow.

The number of processes through which a piece of cotton cloth passes before it finally assumes the beautiful "Turkey-red" colour, is truly surprising. We will follow them rapidly, from the loom onwards. In the first place, the cloth is steeped in a bed of alkaline liquor for several hours, as a means of removing the weaver's "dressing;" next it is washed in a "dash-wheel," then pressed with a force of five hundred tons in a Bramah press to force out the water; next boiled several hours in a hot solution of soap and soda; then washed and pressed, each a second time; and next dried in a room heated to about 140° Fahr. The dried cloth then goes into another building, where another complex series of processes is carried on. The cloth is drawn between rollers, which dip into a vessel containing a solution of soap and Gallipoli oil; and it is then exposed to the action of the open air of a bleach-field. This is the part of the process for which a field of this kind (Fig. 528) is still used. If the object in view were a mere bleaching process, the use of chloride of lime would, doubtless, have superseded this method; but the oxygen of the air seems to act chemically on the ingredients with which the cloth has just been saturated; and this exposure always forms part of the system. The cloth is wheeled to the field, and there spread out on the grass by women. After an exposure of a few hours in this way the cloth is taken up, steeped a second time, dried in a stove-heated room, grassed a second time, then again steeped, dried, grassed, and so on, several times; the solution being slightly varied from time to time, but always being of an alkaline character. After this series the cloth lies steeping for several hours in an alkali bath; it is next washed in the dash-wheel, then squeezed, then drawn between rollers which dip into a vessel containing a solution of sumach, then dried, and then passed through a solution of alum. All this time nothing has been done to actually impart colour to the cloth; all these processes, multifarious as they are, being preparatory. The dye consists chiefly of madder and bullock's blood; and into this solution, in a hot state, the prepared cloth is dipped, and passed through it sufficiently often to imbibe the requisite amount of colour. When the dyeing is effected, it is washed, then boiled for eight or ten hours in an alkaline liquor, then washed again, then boiled again, then washed once more, and lastly, "cleared," or brightened in colour, by being passed through a solution of chlorine.

This may, indeed, appear to the reader a long and most complicated train of proceedings. Every part of it has a particular object in furtherance of the dyeing; the soap, the soda, the Gallipoli oil, the sumach, the alum, the chlorine—all play a particular part in the series; either to heighten the colours of the dye, or to render it permanent, or to contribute in some way to its excellence.

Whatever be the kind of woven material, and whatever the colour, the process of dyeing involves some one or more of these here slightly noticed. Steeping, boiling, pressing, drying—these are the chief kinds of operation, modified according to circumstances.

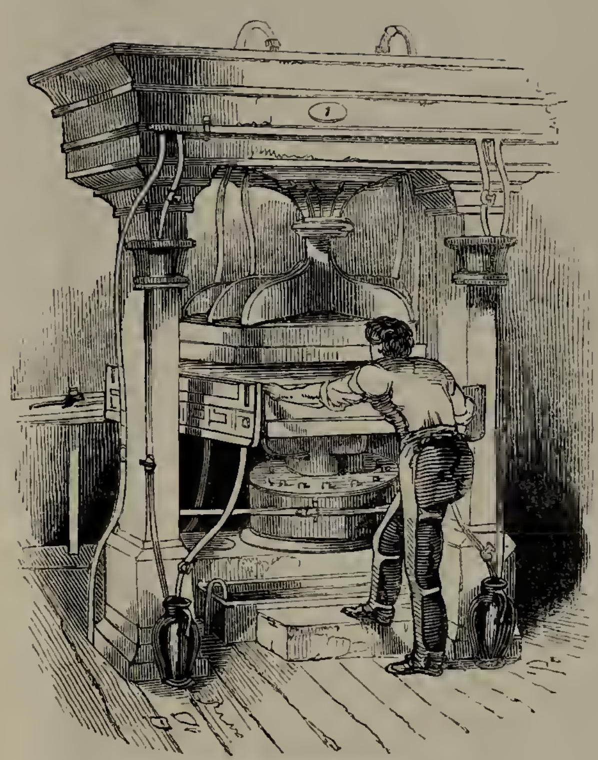
We may next take up that department of our subject which relates to the imparting of *pattern* or *design* to the material; a beautiful art, which has, within the last few years, risen to a high state of excellence.

Early Progress of Calico-Printing.

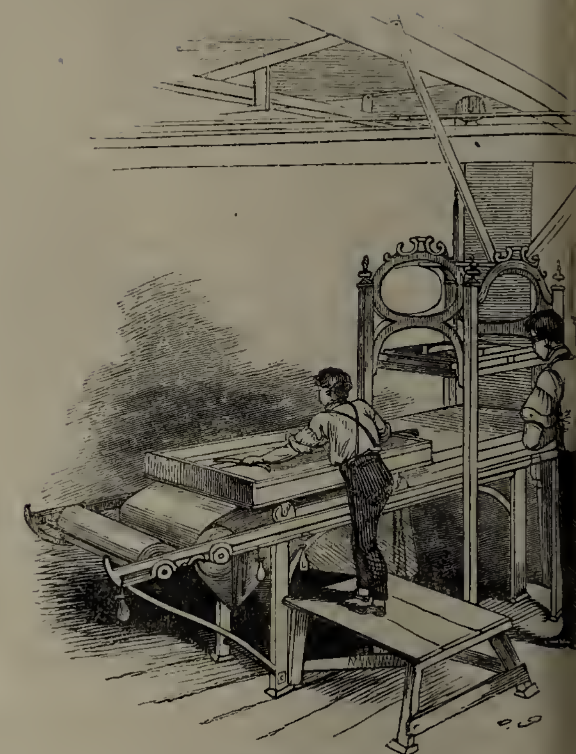
The mode of conducting this art was known to the Hindoos long before anything of the kind had been practised in this country. One of the Portuguese merchants, who went to India several centuries ago, spoke with admiration of the "painted" cottons which the Hindoos produced. A Venetian merchant also, who travelled in India about 1560, speaks of the cotton-cloth as being "painted, which is a rare thing, because this kind of cloth show as they were gilded with divers colours; and the more they be washed the livelier the colour will show."

Father Cœurdoux, a missionary at Pondicherry, gave the following account of the mode practised by the Hindoos in printing, or rather painting their calicoes with colours. The cotton when taken from the loom, was worn next to the skin by the dyer and his family during a space of eight or ten days, after which it underwent several steepings, beatings, washings, and dryings in the sun. It was next soaked for some time in a liquid formed of curdled buffalo's milk and the astringent fruit of the yellow *myrobalans*. After the cloth was thoroughly impregnated with this mixture, it was taken up, squeezed, dried by exposure to the sunshine, rubbed, and pressed. Then ensued a process of painting, by drawing devices on the cloth with a pencil. The liquids used for this purpose were not colours or pigments, but mordants. The first was a mordant of acetate of iron mixed with some palm-wine, and thickened with rice-water: this mordant was applied to the figures or spots intended to become black. Then another mordant was applied to those parts which were to be red; this consisted of alum-water coloured with powdered sappan-wood and thickened with gum. When these

539.—Measuring Calico, before Printing.



538.—Bandana Press, for handkerchiefs.



540.—Calico-printing by the Press.

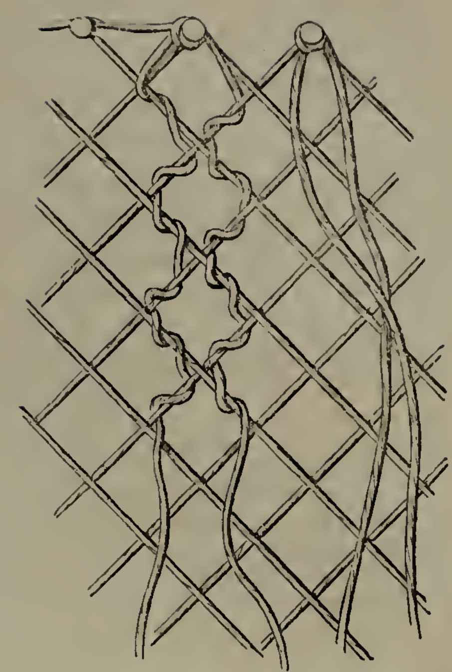
535.—The late Sir Robert Peel, Calico-printer.

536.—Wringing out Yarn, after dyeing.

541.—Calico-printing by the Block.

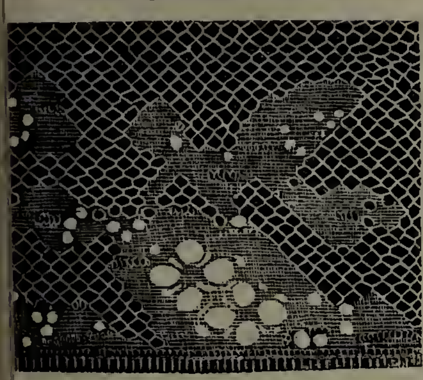
537.—Warp-scouring.

551.—Egyptian Embroidering.

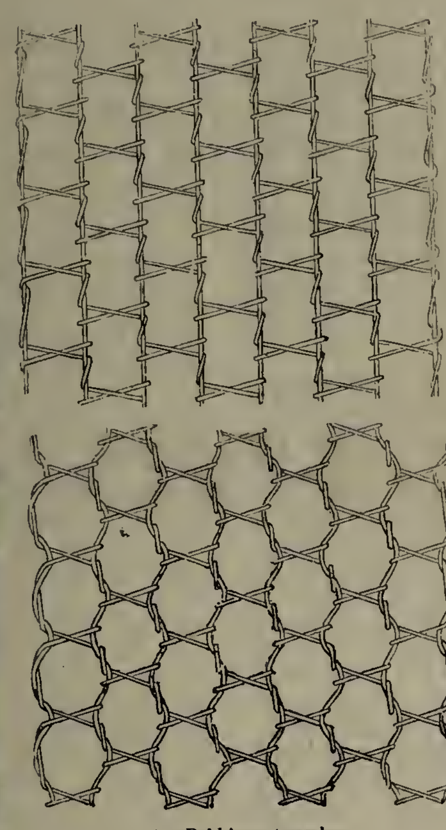


542.—Strings twisted in the manner of Bobbin-net.

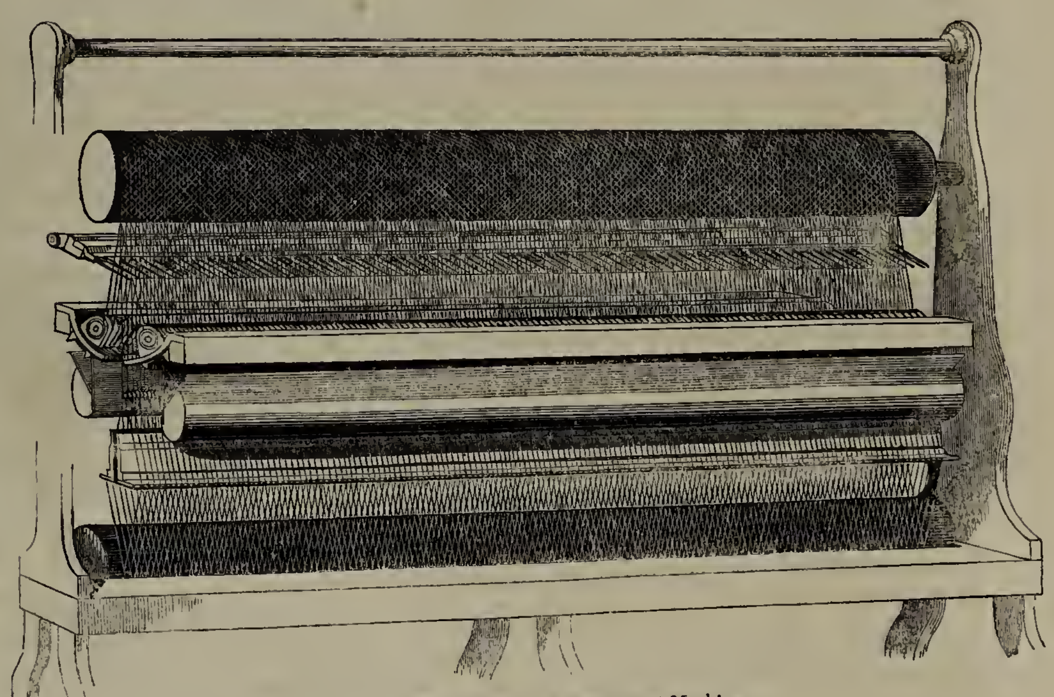
546.—Specimen of Run Lace.



547.—Specimen of Machine Lace.



543.—Bobbin-net meshes.



544.—Working Mechanism of the Bobbin-net Machine.

550.—Nottingham Lace-running or Embroidering.

549.—Egyptian Embroidering.

processes were finished, the cloth was exposed to the hottest sunshine, to dry the parts where the mordants had been applied, and then it was thoroughly soaked in large pots of water to cleanse it from the loose or superfluous part of the mordants. A dye-vat was next prepared, consisting of certain roots boiled in water, and in this dye the cloth was boiled for a long period. The parts which had received the alum mordant were made red; those to which the iron mordant had been applied became black; and the remainder, after being washed and bleached in the sun, became white.

There are not wanting many indications that this art, practised in one or other of the ways consistent with the object in view, has been known among other nations, in some cases from a remote period. Thus Pliny, while speaking of the arts among the Egyptians, says, "Garments are painted in Egypt in a wonderful manner, the white cloths being first smeared not with colours, but with drugs which absorb colour. These applications do not appear upon the cloths; but when the cloths are immersed in a cauldron of hot dyeing liquor, they are taken out a moment after, painted. It is wonderful that although the dyeing liquor is only of one colour, the garment is dyed by it of several colours, according to the different properties of the drugs which had been applied to different parts. Nor can the dye be washed out."

The kind of goods which were first printed in Europe were a mixture of cotton and linen; and the printing was done confessedly to imitate the chintz pattern of India. The art advanced by slow degrees during the first half of the eighteenth century. The calico-printing trade, so far as regards this country, was carried on first in the vicinity of London. It was entered upon in Lancashire about the year 1764, and the second person who embarked in it there was Robert Peel, the grandfather of the present Sir Robert. The history of this family, in respect to their position as Lancashire manufacturers, is interesting: and is thus given by Mr. Baines, in his 'History of the Cotton Manufacture:'—"Mr. Peel was originally a yeoman, farming his own estate, and lived at Cross, afterwards called Peel-fold, near Blackburn. Being of an active and enterprising disposition, he began the manufacture of cotton: and he is mentioned as one of the first persons who tried the carding cylinder. He also took up the printing business; and I have been informed by a member of his family, that he made his first experiments secretly in his own house; that the cloth, instead of being calendered, was ironed by a female of the family, and that the pattern was a parsley-leaf. Stimulated by the success of his experiment, he embarked in the printing business with small means and convenience, and shortly afterwards removed to Brookside, a village two miles from Blackburn. Here he carried on the business for some years with the aid of his sons; and by great application, skill, and enterprise, the concern was made eminently prosperous. His eldest son Robert, afterwards created a baronet (Fig. 535), possessed strong talents, which he devoted assiduously to business from an early age, and thus contributed much to the success of the printing, spinning, and manufacturing businesses; and in each of these branches the Peels soon took a lead in Lancashire. They eagerly adopted every improvement suggested by others, and many improvements originated in their own extensive establishments. As the elder Mr. Peel had several sons, Robert quitted his father's concern about 1773, and established himself with his uncle, Mr. Haworth, and his future father-in-law, Mr. William Yates, at Bury, where the cotton spinning and printing trades were carried on for many years with pre-eminent success, and on a most extensive scale, and are indeed continued, though in other hands, to the present day. Mr. Peel, the father, with his other sons, and another Mr. Yates, established the print-works at Church; and had also large works at Burnley, Sally Abbey, and Foxhill Bank; and spinning-mills at Altham, and afterwards at Burton-upon-Trent, in Staffordshire. So widely did these concerns branch out, and so liberally and skilfully were they conducted, that they not only brought immense wealth to the proprietors, but set an example to the whole of the cotton trade, and trained up many of the most successful printers and manufacturers in Lancashire. The history of the two houses, the Peels of Bury, and the Peels of Church, is indeed the history of the spinning, weaving, and printing of Lancashire for many years."

The Processes of Calico Printing.

There are three or four different modes of imparting coloured devices to the surface of woven cloth; but in all of them the pattern must be prepared beforehand; and this gives rise to the exercise of much artistic skill. *Block*-printing, *press*-printing, *cylinder*-printing, and *bandana*-printing, all require arrangements peculiar, more or less, to themselves. Of block-printing, being the earliest and the most simple, we will speak first.

In this method the device is contained on the lower surface of flat wooden blocks; and this surface, being wetted with liquid colours, and pressed down upon the surface of the cloth, transfers to it a coloured copy of the device. The pattern is formed in "relief" upon the surface of the block, the remaining parts being cut in depression to avoid the colour. Hence the engraving of these blocks becomes a matter of importance. The design is first sketched upon paper and fully coloured. The block (which measures about twelve inches by seven, and consists of a surface of smooth sycamore wood laid on a foundation of some commoner wood) being first carefully prepared, the design is sketched on it, and the tools of the engraver go over it, cutting away all the parts of the surface except those which represent the design itself.

If a design consisted only of one colour, this one block would suffice; but this is rarely the case. Most patterns are combined of many different colours, to which combination they owe a large share of their beauty; and it follows from the nature of the process that each colour must have a block appropriated to it. One portion of the device, say coloured blue, is transferred to one block, another portion to another block, and so on; each block being so cut as to leave those parts in cavity or depressed which are raised in any of the other blocks. Sometimes, where the pattern includes fine lines, it is made out partly by slips of copper wire, which are inserted in the block at proper places.

When the cloth is about to be printed, the bundles are opened, spread out upon a table, the cloth examined and freed from loose threads, measured rapidly over a machine a yard in width (Fig. 539), and sewn together end to end in lengths of twenty or twenty-five pieces. This long piece is wound uniformly round a thick beam or roller, on its way to which it passes over a grooved machine so formed as to take out all the creases, and to make the cloth lie smooth on the beam. This beam is placed near one end of the block-printing table (Fig. 541), in such a manner as to be readily spread out on the table as fast as it is unwound from the beam. At the other end of the table is a tub or pot containing the colour to be used. The colours are obtained from a vast number of chemical and vegetable substances, combined with alkalies, acids, and salts of various kinds, according to the requirements of each particular case. Near the colour-vessel is a circular trough or drum supported by a water-bed or layer to give it elasticity.

Such are the arrangements of the block-printing table; and it will now be easily understood how the printer, aided by a boy or girl, imparts a coloured pattern to the cloth. The attendant dips a brush into the vessel of colour, and spreads a layer equally over the surface of the elastic drum. The printer takes up an engraved block, holding it by a handle at the back, presses it down on the drum, whose elastic surface enables the block to take up an equable layer of colour over its engraved part; and then, laying the wetted surface of the block carefully down upon the cloth, he prints an impression thereon, equal in size to the length and width of the cloth. This done, the attendant again brushes the surface of the drum over with colour, and the printer proceeds as before. At the corners of the block are small guide-pins to assist the printer in the adjustment of the several impressions. All this relates to one colour only, since there is only one colour contained in the vessel; consequently, when the pattern is variously coloured, the printer has to go over it as many times as there are colours, each time with a different block and a different pot of colour from any of the others.

There is an elegant and remarkable kind of block-printed goods called *chiné*, which deserves a little separate mention. The word "chiné," or "chinée," is French, equivalent to "clouded," and alludes to the partial colouring of the warp-threads previously to their being woven; thereby producing an irregular speckled appearance, or a regular design, according to the wish of the operator, but always characterized by a softened and shaded outline. The mode of imparting the colours, as described by Mr. Kemp before the Society of Arts three or four years ago, is as follows:—

The warp-threads being wholly distinct from the weft while being printed, means have to be adopted for holding them out in an even and extended state while receiving the colour; and this is effected by a partial and temporary weaving. The yarn is in the first place wound upon the beam of a loom, and spread out horizontally just as if for common weaving. The weaver then proceeds to weave very narrow strips, half or three-quarters of an inch in width, at intervals of a foot asunder; so that the whole length of the piece, when finished, consists of alternations: first a strip of woven cloth or silk less than an inch in width, then twelve inches of warp-threads free from any weaving, then another narrow woven strip, then another foot of unwoven warp, and so on. These narrow strips are simply for the purpose of keeping the warp-threads together while being printed, and answer no other object. While this is being done, the warp is very carefully examined from time to time, and all loose hairy filaments, spots, or imperfections removed, since the printing ought to be upon a perfectly clean and prepared surface. When matters are so far ready, the warp is wound upon the cloth-beam, and in that state placed in the hands of the printer. He fixes the beam near one end of his printing-table, in such a way that the warp, as unwound from it, may pass over the surface of the table, and thence to another beam or roller. The printing is done on the block-method. The table is covered, first with a blanket, then with an oiled or painted cloth, and lastly with a piece of clean white calico on which the warp rests while being printed. When one table-length of the warp has received its impress, it is moved on towards the beam on which it is to be wound, another equal length is unwound, and a clean piece of calico placed beneath it, to prevent the smearing of the warp by the superfluous colour on the former piece of calico. The printed warp becomes partially dried in its progress to the large roller: it is then wound off into the form of a large skein and subjected to a process of "steaming," by which the colours are fixed. It is then sewn up in a canvas bag, and well washed. After being dried, it is given back to the weaver, who proceeds to fix it in his loom as before, stretching the warp-threads out in their proper order, which he is enabled to do by the few woven stripes still remaining. These stripes he picks out one by one, and proceeds to weave the whole piece in the usual manner. The result of this series of arrangements is, that the warp-threads retain the coloured pattern given to them by the printing, and the pattern acquires a peculiar softness of appearance when the weft is interwoven with it.

The press-printing of calico (Fig. 540) differs in many respects from the block-method. In the first place a model is formed from the design, comprising as much of it as may be included within a space five inches long by an inch and a half wide. This model is formed of bits of metal inserted in a foundation or block, and a mould is produced by stamping from the model. The mould so made, is fixed in a block or case, and stereotype casts or copies are taken from it in a mixed metal of tin, lead, and bismuth. When a sufficient number of these pieces are prepared, their surfaces are filed down to a perfect level, and they are firmly fixed down upon a stout smooth piece of wood. In the next place, to show how these are used, we will suppose that there are four different colours in the device to be printed. Four sets of stereotype casts are prepared, each set being for the imprinting of one colour, and all four combining to form one pattern or device. A tablet of wood is prepared, two or three feet square, and on this all the casts are fixed: all the pieces for one colour are arranged in one row or stripe, five or six inches in width; all those for another colour in another row, contiguous and equal in width to the former; and so on for the third and fourth. The length of each stripe is about equal to the width of the cloth; and the whole forms a compound printing-block divided into four compartments.

In printing by this method a machine of somewhat delicate adjustment is employed. The block is fixed face downwards to the bottom of a descending frame capable of receiving a vertical motion; and the calico being laid smooth on a table beneath, the block is brought down at intervals upon it, by the aid of a lever managed by the workman. So far for the actual printing. The colour arrangements are ingenious and curious. At the end of the table are four (supposing, as we do for illustration, four to be the number) little troughs containing the four colours, one in each. A boy is provided with a long piece of wood so formed as to dip into all these four troughs and to take up a small portion of colour from each, which he drops upon a flat cushion covered with flannel or felt; he next, with a kind of brush, spreads out these four colours in an equal number of oblong patches over the surface of the felt, which the arrangement of the machine enables him to do without smearing the colours one over another. This cushion, coated with its party-coloured layer, is next wheeled along a miniature railway, until it comes beneath the block contained in the press; the printer lowers the block until it rests on the wetted surface, and thereby acquires a coating of each kind of colours; the arrangements being so exactly managed that each portion of the device shall fall on one colour only. The printer then raises the block again; the boy quickly withdraws the cushion, and the wetted block is allowed to fall on the surface of the cloth, thereby imprinting four stripes or portions with four different colours, one to each. By an attached piece of mechanism the cloth is shifted on to a distance equal to the width of one stripe; so that, at the second stage of printing, each colour may have moved on one stage. Supposing the four colours to be blue, red, yellow, and green, then one strip of cloth has received its blue impress at the first printing, and its red at the second; a second strip has received its blue and its yellow, a third its blue and its green. By this means the cloth receives all its colours throughout its whole length by degrees. This interchange is somewhat difficult to represent to the mind; but it will become intelligible by remembering that each portion of the cloth is brought successively into contact with each of the four divisions of the block.

In cylinder-printing (Fig. 534) the process is conducted more continuously and more expeditiously than by either of the two methods just described. We will, as before, speak of one colour only. There is at the lower part of the printing-machine a hollow copper

cylinder, about five inches in diameter by thirty or forty inches long. On this is engraved the device which is to be transferred to the cloth; not in relief, as in the former cases, but in cavity, as in the usual copper-plate engraving. Two methods are adopted of giving the device to the cylinder. In the first and original method the exact circumference of the cylinder is taken by a piece of paper, and on this paper is copied the design, so chosen that exactly one repetition, or a complete number of repetitions of the design, may equal the circumference of the cylinder. On this paper the device is sketched, and is from thence transferred to the surface of the cylinder in a manner sufficiently distinct to guide the engraver in engraving it. In a more modern method, advantage is taken of the valuable principle by which steel plates are multiplied. A small steel cylinder, about three inches long by one in diameter, is engraved with as much of the device as its surface will contain; this being done while the steel is in a soft state. The steel is then hardened, and pressed or rolled very forcibly against a soft steel cylinder, by which an obverse impression is given to the latter—that is, raised instead of depressed. As the original die was at first in a soft and then in a hard state, so this second cylinder, which is called the "mill," receives its impress while in a soft state, and is then hardened before being applied to its subsequent purpose. This purpose is, to impress the device upon the surface of the large cylinder which is to be employed in printing. The "mill" is applied successively to different parts of the cylinder, so as to give an engraved surface to the whole.

A cylinder, then, engraved in one of these two methods, is so placed in the lower part of the cylinder-printing machine as to dip into a trough containing colour. The cloth, descending from a beam above, passes in close contact with the wetted cylinder, and receives colour from it; but in order that this should only occur from the engraved parts of the cylinder, a smooth knife previously removes all the superfluous colour from the other parts. The cylinder continues to revolve in the trough containing colour, and the cloth continues to pass over and in close contact with it; so that the process of printing goes on uninterruptedly. If the pattern comprises several colours, there is a trough for each colour, and a cylinder for each trough: the cloth passes in succession over all the cylinders, and imbibes a definite coloured-pattern from each.

In some patterns of a delicate and complicated kind two or even all of these methods are adopted; one colour being printed by the "block," another by the "press," and others by the "cylinder." In some cases, too, the device which is printed is given in colours; in other cases it is formed of a "mordant," intended to enable colours to unite with the cloth; in others it is a "resist," that is, a mixture which is to prevent the colour with which the cloth is afterwards dyed from attacking certain parts; in others, again, it is a "discharger," that is, a mixture intended to discharge or remove colour from any particular spot. There are here, therefore, four varieties of proceeding, namely, to impart colour, to remove colour, to enable the cloth to receive colour, and to enable it to resist colour; and these give to the calico-printer an extensive choice as to his mode of proceeding.

A beautiful example of the "discharge" method is afforded by the Bandana handkerchiefs so well known, in which white or yellow spots occur on a red, blue, or green ground. In producing these patterns, the cloth is first dyed uniformly all over, and is then folded in piles containing fourteen layers or thicknesses. This thick layer is wound on a beam, from which it is unwound in portions measuring about a yard square, and placed upon the bed of the Bandana hydraulic press (Fig. 538). This bed-plate is capable of being forced upward with irresistible power, to such a height that the cloth is brought into close contact with a horizontal frame over it. This frame has a series of holes corresponding with the pattern of the handkerchief; and the arrangements of the machine are such, that when the cloth is pressed tightly between the two surfaces, liquid chlorine flows through the holes in the upper surface, and then through the fourteen thicknesses of cloth, removing the colour as it goes. It is found afterwards that all the spots which have been touched by the chlorine become perfectly white; except in cases where the chlorine is purposely mixed with some substance which shall give a yellow colour to the spots.

LACE, EMBROIDERY, TAPESTRY, AND HOSIERY.

The reader will have observed, that all the processes of spinning, weaving, printing, and dyeing, glanced at in the preceding pages, refer to one or other of the four principal fibrous materials; and that these materials are woven into a tolerably close textile fabric. But there are some other curious varieties, applied to clothing, which call for a little attention.

If we take a few specimens of pillow-lace, bobbin-net, tamboured muslin or net, tapestry, knitting or hosiery work, and embroidered silk, we shall find that either a ground or a device is produced by an arrangement of threads very different from that observed in common woven material. In the first and second there is a series of meshes or openings between the threads; in the third and fourth there is a device produced by interlacing threads in a definite manner; in the fifth there is a kind of chain-work intermixture of threads, mediate in kind between lace and common woven goods; and in the sixth there is an ornamental device of threads worked into or upon a silken material previously woven in the usual manner.

Lace and Bobbin-Net.

The time seems to be passing away when cottagers may be seen at their own doors engaged in lace-making. Nottingham has effected so complete a revolution in this kind of work that, cheap as country labour may be, it cannot stand against the cheapness of machinery. The "pillow-lace" of the cottagers is measured by yards—the "bobbin-net" of the manufacturers is measured by thousands of yards; and, as in other cases, the facility of production determines the character which the manufacture takes. Still, however, there are points of superiority in hand-made lace which keep up a limited demand for it.

The hand-made lace has several names, according to the mode in which the meshes are formed. Thus, there are the "Brussels point," "Brussels ground," "Brussels wire-ground," "Mechlin," "Valenciennes," "Lisle," "Alençon," "Alençon point," and others. In the making of these various kinds the workwoman has before her a round or oval board or plate, so stuffed as to form a kind of pillow, which is placed either on a table or on the lap. On this pillow a stiff piece of parchment is placed, and holes are pricked through the parchment in conformity with the intended pattern of the lace. Through these holes pins are stuck into the pillow. The threads with which the lace is formed are wound upon small bobbins; and from these bobbins the threads are twisted around the pins and around each other in various ways, so as to form a pattern of meshes, constituting the groundwork of the lace. The device, however, which forms so notable a part of pillow-lace, is formed by interlacing a thread, much thicker than that forming the groundwork, among the meshes.

It is to imitate this kind of entanglement of threads that the "bobbin-net" machine was invented, and the invention certainly ranks among the most ingenious presented in the Arts. The term "bobbin" net has relation to some of the mechanism employed. In the earlier state of the manufacture there were several kinds, deriving their names from various sources; such as the "two-plain net," "square net," "tuck-knotted net," "fish-mesh net," "plaited net," "point net," and "warp net."

If we look what the bobbin-net machine has to effect we shall see that it consists in the coiling of one set of threads round another. For instance, in Fig. 542, supposing two sets of threads to be crossed nearly at right angles, and another set to be coiled round both of them in succession, it would produce something like an appearance of net. Again, in Fig. 543, if the vertical threads were rigid, and the cross-threads coiled around them diagonally, it would produce some such a net as the upper of the two specimens; whereas if the vertical threads were flexible, they would be thrown into the form shown in the lower specimen, much more closely resembling bobbin-net. The machine by which this is effected (of which part is shown in Fig. 544) is a singularly complex piece of mechanism. There is one series of threads ranged vertical in the machine, side by side, and another series wound on brass bobbins so exceedingly thin as to pass between the threads of the former series. The bobbin-threads are made to pass to and fro between the vertical threads, and to twist around them by a combination of movements, which for complexity has few parallels in any other art. The vertical threads shift laterally to and fro; the bobbins have a backward and forward motion like the pendulum of a clock; and the frame to which they are all attached has itself a distinct movement. Sometimes there are as many as three or four thousand bobbins to one machine, capable of making net five yards in width.

To make the plain net, however, is not the only office of these machines. They are now brought to such perfection as to embroider the net with a pattern while making the net itself; and this pattern is in some cases so produced as to render it difficult for the eye to determine whether the embroidery has been produced by the machine or by hand. Fig. 546 was copied from a piece of net, or lace, which had been embroidered by hand; while Fig. 547 is a copy of a specimen made wholly in the machine.

After the bobbin-net has been made in the machine, it undergoes many processes before being sent to market. It is "gassed" or singed, for the removal of the little hairy filaments from the surface of the cotton threads; and is then slightly printed with the pattern or device which is to be worked on it by the embroideresses. It is, when embroidered, examined to see whether there are any defective meshes or threads; then bleached if to be white, or dyed if to be black; and lastly, when bleached, taken to the "lace-dressing rooms" (Fig. 548), where it is dipped in a stiffening mixture of gum and paste, and stretched tightly over a horizontal frame. When finished, it is cut into saleable shapes and sizes, and finally rolled and pressed.

Embroidery Work.

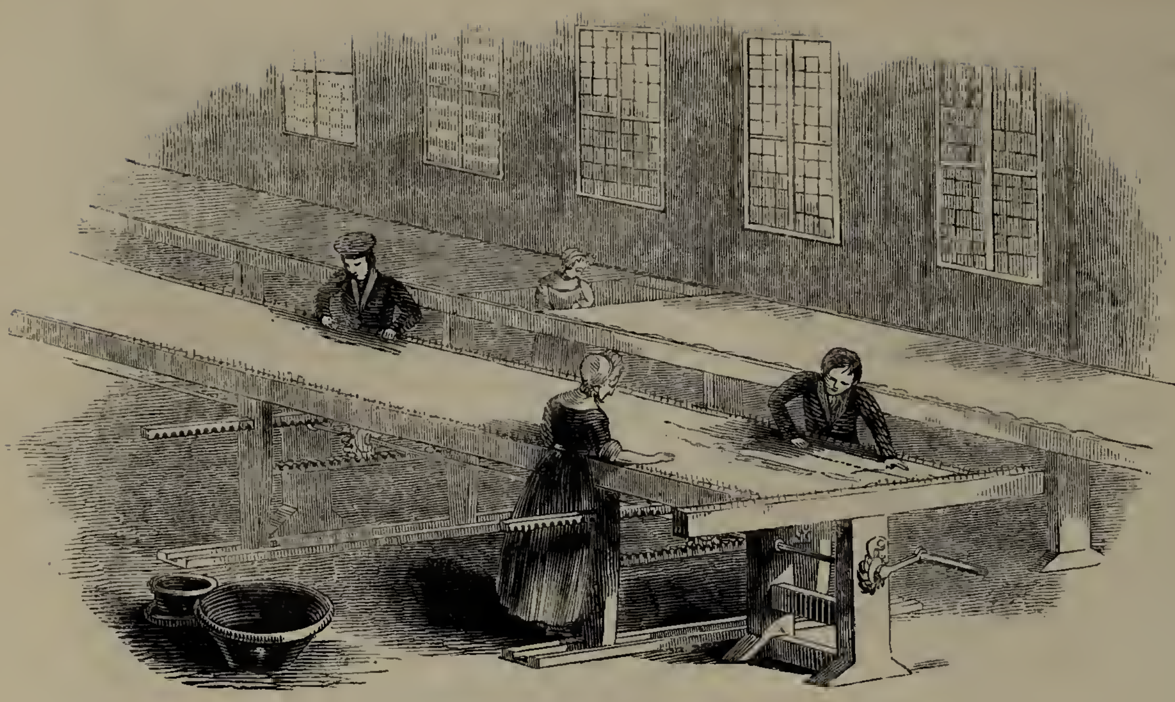
The embroidery to which we have just alluded is a kind of needle-work practised in many countries from very early times. In all cases it consists in imparting a pattern to a woven or netted material, by means of threads used with a needle or else with a small hook. There is an obvious similarity between the two scenes sketched in Figs. 549 and 550, although the one occurs in Cairo and the other in Nottingham; but Fig. 551 shows a mode of proceeding differing a little in details though not in principle.

In most of the Oriental nations the art of embroidery is much valued and practised. The Egyptian women embroider by means of a frame called the *menseg* (Fig. 549), made, among the poorer classes, of beech, but among the higher, of walnut-wood inlaid with mother-o'-pearl and tortoiseshell. Mr. Lane, in his 'Modern Egyptians,' says, that the leisure hours of the Egyptian ladies "are mostly spent in working with the needle, particularly in embroidering handkerchiefs, head-veils, &c., with coloured silks and gold. Many women, even in the houses of the wealthy, replenish their private purses by ornamenting handkerchiefs and other things in this manner, and employ a *della' leh* (a female broker) to take them to the market, or to other hharee'ms for sale." The same writer states, in his 'Notes to the Arabian Nights,' that in all Mohammedan countries the processes of spinning, weaving, embroidering, and needle-work are taught among the most important of the duties devolving upon females; and that many of the tenets of that faith are so framed as to encourage these employments. One of the doctrines is, that "sitting for an hour employed with the distaff is better for women than a year's worship; and for every piece of cloth woven from the thread spun by them, they shall receive the reward of a martyr."

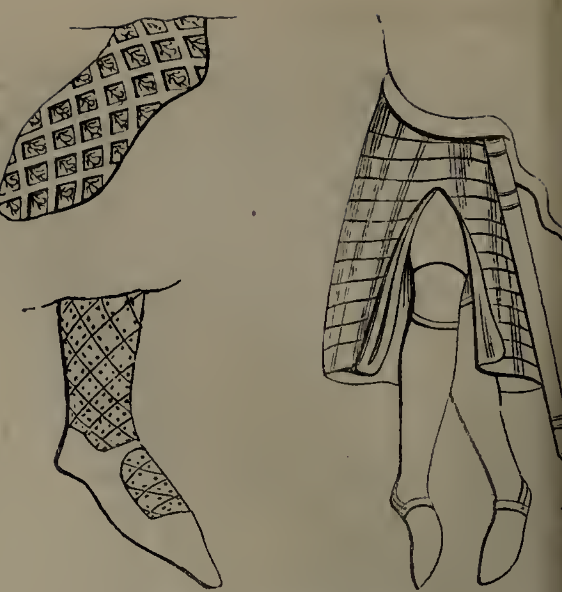
Mr. Tradescant Lay, in his recent work on 'China and the Chinese,' states that the art of embroidering is largely carried on by the females of that country. He purchased a book which had been published expressly to aid in the development of this art, since it contained between two and three hundred designs for embroidery-patterns: it was intended for the humbler class of embroideresses, and was therefore published at an extremely low price. Mr. Lay says: "I once saw two girls at this work in the village of Mengha. They were seated upon a low stool, and extended their legs across another of twice the height of their seat. In this way a support was provided for the frame on which the piece to be embroidered was spread forth. Their faces wore a sickly hue, which was owing perhaps to close confinement and the unnatural position in which they were obliged to sit. The finest specimens of embroidery are, as far as my observation goes, done by men, who stand while they work—a practice which these damsels could not imitate, as their feet were small. They were poor, but too genteel in their parents' idea to do the drudgery of the humble housewife, and so their feet were bandaged and kept from growing beyond the limits of gentility. Their looks were not likely soon to attract a lover, and hence they were compelled to tease the sampler from the glistening dawn to dewy eve. Much skill and labour are bestowed on the embroidery of a plaited skirt worn by ladies, which, with my partiality for what is Chinese, I think without a rival for beauty as an article of female attire. In the little work before me several patterns are given expressly for this purpose. A curious purse worn in the girdle of Chinese gentlemen is also the subject of much of this kind of elaboration." Fig. 552 represents some such a purse as those here alluded to. We may here remark that if the specimens of embroidered silk displayed at the Chinese Exhibition are really the work of that singularly ingenious people (and there seems no reason to doubt it), we must give them credit for a very high degree of skill in this art.

In the practice of embroidery, the material is either stretched over a portable hoop, or over a horizontal frame. In Fig. 551, for example, where men are represented embroidering (for in Egypt the men produce finer specimens of this work, as a branch of trade, than the females), the material is stretched by cords attached to hoops; whereas in the other wood-cuts it is represented as being extended over a horizontal frame, at one side of which the embroideress sits. At Nottingham the bobbin-net is stretched on the frame, and the workwoman, with her left hand under the net and her right above it, works the pattern by means of a needle and a thick kind of cotton thread, following the lines of the device which had previously been slightly stamped on the upper surface of the net. This employment is known at Nottingham by the name of "lace-running," while another variety of the work, in which thread is interlaced among the meshes of the net by means of a small hook instead of a needle, is called "tambouring."

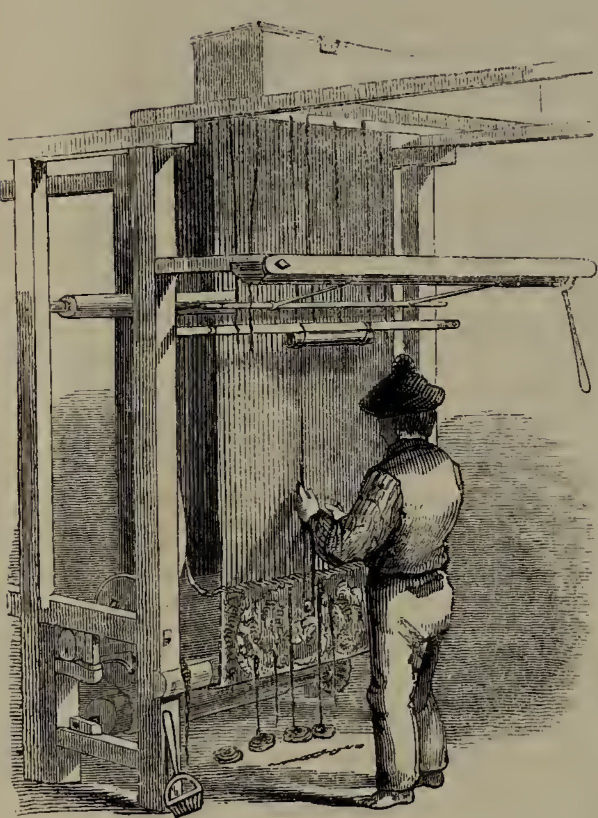
The employment of embroidering muslin is carried on extensively in the North of Ireland. Glasgow manu-



548.—Lace-dressing at Nottingham.



557.—Hosiery in the Fourteenth Century.



553.—Persian-rug making.

555.—Anglo-Saxon Hosiery.

558.—Hosiery in the Fifteenth Century.

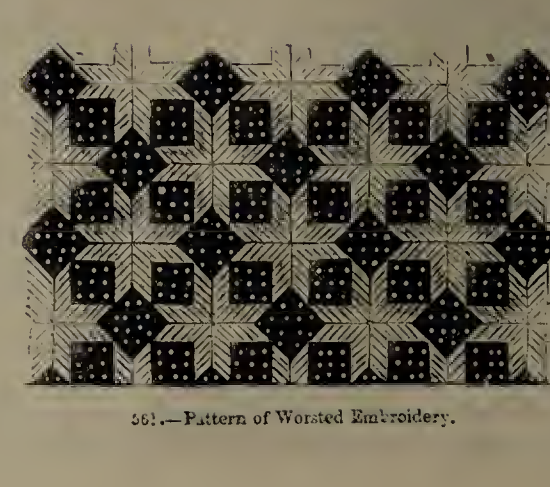
556.—Hosiery in the Thirteenth Century.

554.—Persian-rug Pattern-paper.

559. -Gloves, Sixteenth Century.

550.—Anglo-Saxon Ornamental Design.

552.—Embroidered Chinese Purse.



561.—Pattern of Worsted Embroidery.

564.—Pattern of Worsted Embroidery.

565.—Pattern of Worsted Embroidery.

566.—Patterns of Worsted Embroidery.

562.—Anglo-Saxon Ornamental Design.

563.—Anglo-Saxon Ornamental Design

567.—Chinchilla: yielding Hatters' Fur.

568.—Coypus: yielding Hatters' Fur.

570.—Fibre of Beaver-fur, magnified.

569.—Beaver: yielding Hatters' Fur.

facturers have the muslin woven in or near that town, and then send it over to Belfast to be "worked" or embroidered by the humbler classes of females in the neighbourhood, who will do this work for a lower rate of payment than the Scotch. Mrs. S. C. Hall, while describing one of the northern counties of Ireland, says: "Through the whole of this district, the barony of Ards and that of Castlereagh, a large proportion of the peasantry are employed in what is technically termed 'flowering,' embroidering muslin, chiefly for the Glasgow manufacturers, who supply the unwrought material, and pay fixed sums for the workmanship. The workers earn generally about three shillings a week; a small sum—but, as the majority of the inmates of a cottage are similarly employed, sufficient is obtained to procure the necessaries of life, and indeed some of its luxuries, for the interior of many of the cabins presented an aspect of cheerfulness and comfort."

Embroidering has been often attempted to be done by machinery. Forty years ago Mr. Duncan devised a machine for this purpose, but from various causes it failed. There is at the present day a beautiful machine in use in some of the Manchester factories, whereby silk can be embroidered in a very beautiful manner; the machine is an extension of the drawing instrument called a "pantograph," and produces the embroidered pattern very much more rapidly than it could be produced by hand.

Tapestry Weaving.

It is not always easy to keep clear from confusion in distinguishing *embroidery* from *tapestry*, from a want of bearing in mind the following point—that in embroidering a device is produced by threads on a material already woven or netted; whereas in tapestry the material itself is made at the same time and by the same means as the device is formed. In embroidery the work is done only *partly* over the surface of the material, whereas in tapestry the work covers every part.

Tapestry has acquired a fame which would not otherwise necessarily attach to it, from the circumstance that painters of the first eminence have occasionally furnished designs for the workmen. This design is always drawn on paper or pasteboard; and such a paper, called a "cartoon" or "carton," is the pattern from which the work is done. The cartoons of Raffaelle at Hampton Court ("the glory of this country, and the envy of every other," as they have been called) were painted for this purpose: we shall speak of them more particularly presently; but it may here suffice to say that the word "cartoon," as applied in the fine arts, generally means a coloured drawing on paper, originally intended as a pattern for tapestry-weavers. The walls of rooms were not covered with printed or stained paper until about two centuries ago: before that period the more costly apartments were covered with tapestries, which are in fact cloth pictures; and it is not surprising that attempts should be made to give pictorial beauty to such productions.

"The first manufactories for weaving tapestry which acquired reputation in Europe," says Miss Lambert ('Handbook of Needlework'), "were those of Flanders, and they appear to have been long established in that country, particularly at Arras, before they were introduced either into England or France: the precise period when they were first manufactured by the Flemings is uncertain. Guicciardini, in his 'History of the Netherlands,' published at Antwerp in 1582, ascribes to them the invention of tapestries, but without mentioning any particular date. Whether the Flemings did or did not derive their knowledge from the East, to them is certainly due the honour of having restored this curious art, which gives a life to wools and silks scarcely if at all inferior to the paintings of the best masters. The weaving of tapestry was first introduced into England in the time of Henry VIII. by William Sheldon; but it was not until the reign of James I. that it acquired any particular reputation. This monarch greatly patronized the art, and gave the sum of two thousand pounds towards the advancement of a manufactory which was established by Sir Francis Crane at Mortlake in Surrey. The patterns first used for making these fabrics in England were obtained from pieces which had already been worked by foreign artists; but as the tapestries produced in this country acquired greater celebrity and perfection, the designs were furnished by Francis Cleyn, who was retained for that purpose. There is extant in Rymer's 'Fœdera' an acknowledgement from Charles I. that he owed Sir Francis Crane the sum of six thousand pounds for tapestries, and that he grants him the annual sum of two thousand pounds for ten years, to enable him to support his establishment."

It is to the "Gobelin tapestries" of France, however, that the greater amount of attention has been directed. Henry the Fourth or "Henri Quatre," being desirous to improve and advance the industrial arts in France, established many manufactories, and among others one for tapestry. This was soon after the commencement of the seventeenth century; but after the death of Henry the manufacture languished, and did not revive until 1663, when Colbert, minister to Louis XIV., gave a new impetus to it. He was influenced not so much by the wish of establishing a permanent manufacture, but by a desire to obtain a supply of good tapestry for the royal palaces at the Louvre and the Tuileries. Two brothers, Giles and John Gobelin, had occupied a building for the processes of dyeing; Colbert bought this building; and as it was known as the "Hôtel des Gobelins," the name of Gobelin became afterwards attached to the tapestry made there. Talented artists, dyers, and weavers were brought thither from Flanders to superintend the various processes. Soon afterwards the celebrated painter Le Brun was appointed chief director, and gave to the tapestry a beauty and grandeur of design befitting his great talents. Among the subjects wrought at the Gobelins from the designs of Le Brun were, "Alexander's Battles," the "Four Seasons," the "Four Elements," and the "History of the principal Acts of Louis XIV. from his Marriage to his first Conquest of Franche Comté." Cabinet pictures, by the great Italian masters, were copied on a large scale by French painters as cartoons for the Gobelin weavers. The dyeing of the wool and silk, and all the processes connected with the manufacture, were conducted within the walls of the establishment. The manufacture was kept up throughout the next following century, to a greater or lower extent; it suffered an overturn during the Revolution; but was revived by Napoleon, who had some tapestry worked for his palace at St. Cloud. The change of taste, however, by which painted and papered walls have nearly superseded those hung with tapestry, has placed this art comparatively in the shade in modern times.

In the making of tapestry two methods are adopted, known by the French names of the "basse-lisse" and the "haute-lisse," equivalent to "horizontal warp" and "vertical warp." The latter was the mode adopted at the Gobelins, and is thus conducted. There is an upright frame about eight feet in height, on which the warp-threads of the material are stretched vertically; while there are contrivances at the sides for opening the warp-threads to admit the cross-threads between and among them. These cross-threads are of various colours, and are worked in by hand in such places as will give a coloured copy of the picture from which the tapestry is to be worked; a tracing of the drawing is made upon the layer of warp-threads sufficiently distinct to guide the workman. The cross-threads, which are made of gold, silver, or coloured silk, are wound round a kind of shuttle called a "broach," one broach to each colour. The workman places himself behind the warp, and has the drawing or cartoon hanging up behind or by the side of him. Before he begins to use his threads he turns to look at the drawing; and then taking a broach of the proper-coloured thread, he interweaves it among the threads of the warp, according to the form and extent of the piece to be represented. When he comes to a different colour, he adopts a means of fastening the thread last employed, and takes another broach containing the second colour; and so, according to the exigencies of the drawing. He employs at intervals a sort of comb, the teeth of which he passes between the threads of the warp, to drive the cross-threads close up one to another. From time to time he passes round to the front of the frame, to see the effect of his work, and to compare it with the drawing. When he has completed a portion of his work, he winds it round the lower end of the frame, and unwinds more warp from the upper end.

In the horizontal or "basse-lisse" mode of proceeding, the warp is stretched horizontally, with the drawing immediately underneath; so that the workman can see the device which he has to copy without turning his head. The tapestry woven in bygone times at Arras in Flanders (which became so celebrated as to give the name of "Arras" to the hangings themselves) was made in a somewhat different manner. The device was not woven at once, but was wrought in small and separate pieces; the leaves and smaller objects of the tapestry forming so many distinct patterns tacked together, but with such skill as to render the joints almost invisible. Under any circumstances, however, the process must of necessity be an extremely slow one; and we can hardly feel surprised if, in an age when almost everything is conducted on the "high-pressure" system, such a time-consuming art has been laid somewhat in the shade. Some of the ancient pieces of tapestry occupied several years in making.

The "basse-lisse" mode of working tapestry bears some slight resemblance to embroidery and lace-running, in so far as concerns the position in which the workman and his work are placed. But the "haute-lisse" method is still better assimilated to the making of "Persian rugs," carried on at the present day in Glasgow and elsewhere. In making these rugs there is no woven material employed; but the warp-threads, made of linen yarn, are stretched vertically in a frame (Fig. 553). The boy (for this is work which boys can do) has a rolled-up paper just above the level of his eye; and this paper, when unrolled a little at a time, exhibits a pattern from which he is to work, such for instance as that in Fig. 554. There are a few cross-lines in this figure; and these will serve to indicate the manner in which a much larger number are employed to represent warp and weft threads, as in Berlin patterns. The weaver is provided with stout worsted yarns of various colours, which he twists round the separate warp-threads, and cuts off with a pair of scissors. He looks at the pattern from time to time to see what colour occurs at a particular spot, and twists in a bit of worsted at that spot. When he has made one row of such tufts from edge to edge of the extended warp, he weaves in two or three threads of strong linen weft, and then proceeds as before. The ends of the little tufts are afterwards cut off to a smooth level, and they wholly hide the intervening linen threads. In some respects, therefore, it will be seen that this art bears a little similarity to "haute-lisse" tapestry weaving.

Celebrated Specimens of Tapestry.

It may well be supposed that the art of tapestry weaving, calling forth the talents of painters and the munificence of princes, produced many specimens which have excited a kind of historical interest, since in many cases they represent vividly to us the persons, the scenes, and the dresses of the age in which they were produced.

The Bayeux tapestry, one of the most singular examples of queen-like industry, is not rightly called tapestry at all, since it is a specimen of embroidery with the needle on woven cloth. This piece of needlework was presented by Matilda, Queen of William the Conqueror, to the cathedral of Bayeux, the canons of which were accustomed to exhibit it to the inhabitants of the city, in the nave of their church, at a particular season of the year. It consists of a continuous web of linen cloth, 214 feet by 20 inches wide, and on it is a representation of various events connected with the invasion and conquest of England by the Normans, worked (as is supposed) by Queen Matilda and her attendants with needles and woollen thread.

One of the remarkable old specimens of tapestry (properly so called) was unfortunately destroyed a few years ago. After the defeat of the Spanish Armada, nearly three centuries ago, the government, anxious to record so notable an event, employed a Dutch painter at Haarlem, named Henry Cornelius Vroom, to design ten cartoons with a representation of the battle. Tapestries were worked from these cartoons in Flanders; and these tapestries decorated the walls of the House of Lords until the destruction of that building and of the tapestries by fire in the year 1834.

In St. Mary's Hall at Coventry is a piece of tapestry representing some of the events in the life of Henry VI. It is thirty feet long by ten in height, and is divided into six compartments, three in the upper tier and three in the lower. The citizens of Coventry supported that monarch in his troubles; and it is supposed that this commemorative tapestry was placed in the hall during or soon after his reign.

At Penshurst, near Tunbridge, the fine old mansion of the Sidneys, where Sir Philip Sidney once resided, are some fine specimens of Gobelin tapestry. They are two in number, and of very large size; the subjects being the "Triumph of Ceres" and "Eolus unbarring the Winds." They have been much and generally admired for the excellent drawing of the figures, the colours, and the general harmony of expression; and it is supposed they were executed at the time when Le Brun was director of the Gobelin establishment.

At Cassiobury, the fine seat of the Earl of Essex near Watford, the state bedchamber is hung with Gobelin tapestry representing agricultural subjects. One picture or piece of tapestry represents ploughing and sowing; a second introduces us to haymaking; a third, larger than either of the others, groups together many farming operations; while the fourth and principal picture is a copy from Teniers' "Village Feast," exhibiting the hilarity of a harvest-home. Such subjects as these were not so often adopted by the tapestry designers as others in which Allegory or History played a part.

Without attempting to enumerate the various specimens contained in many of our English mansions, or in foreign countries, it may suffice to say that many such are contained in Hampton Court Palace. In the first Presence Chamber, the King's Audience Chamber, the King's Drawing-room, and others of the state apartments, pieces of tapestry are (or were) hung upon the walls. Of these, the specimens contained in Wolsey's "Withdrawing Room" are described at some length in Mr. Jesse's 'Summer-day at Hampton Court.' It is remarked that, independent of the interest attached to these tapestries from the name of their once famous possessor, "they are remarkable in many respects for the merit they possess as examples of design. Allowance must of course be made for the style of art of the period, and the peculiar manner of the school which produced them. They are characterized by a Gothic taste, and by a somewhat lengthy and stiff proportion and form in the figures, which is found in almost all the earlier and in many of the later works of the Flemish designers (for these tapestries may be cer-

tainly attributed to that school). . . . . Yet with all these drawbacks, these tapestries possess qualities which the real artist and connoisseur will immediately recognize as worthy of study and attention. The vigour of some of the groups and single figures, the expression of many of the heads, the feeling for simple and often elegant form, and also the exceeding grace and beauty of disposition and arrangement of many of the draperies, to say nothing of the bold, though, it must be admitted, often strange conception of the allegories—afford fair compensation for many of the defects which arise out of ignorance of, or want of practice in, true drawing, and the absence of a grander and purer style. They prove also that the authors of such designs were artists of no mean power, however inferior they must be considered to the mighty master-spirit from whom emanated those splendid compositions of a more severe and refined school, which, designed also for tapestries, are preserved in another apartment of the palace."

The "Cartoons of Raffaelle," also deposited at Hampton Court, are perhaps the most celebrated of all existing examples connected in any way with tapestry. Their history is simply as follows:—

Pope Leo X. employed Raffaelle to design a series of subjects from the New Testament, twenty-five in number, as cartoons or patterns from which tapestry-weavers might work. When finished they were sent to Brussels, and the tapestry made from them at an expense of seventy thousand crowns. Before they were quite completed both Leo and Raffaelle died; and the succeeding pope, who had but little taste for the fine arts, neglected the cartoons, which were left to decay in unaccountable neglect. At a later period they were brought under the notice of Charles I. by Rubens, and this monarch purchased them, and brought them to England. After the time of Oliver Cromwell they were again neglected and injured; and were, at length, by William III., placed in a gallery in Hampton Court built expressly for them, where they have ever since remained. Although these are called *the* Cartoons of Raffaelle, they comprise only seven out of the original number of twenty-five; two are in the possession of the King of Sardinia, one is in a private collection in England, and the other fifteen are supposed to be wholly lost.

Of the tapestries worked from these cartoons two sets were completed, the one for the adornment of the Vatican at Rome, and the other as a present to Henry VIII. The first set underwent many vicissitudes, having been twice forcibly taken away during time of war, and again restored to their former depository, where they still remain. The second set were sent over to Henry VIII. in England, were hung up in Whitehall, and descended as a royal appanage through the reigns of Edward VI., Mary, Elizabeth, James I., and Charles I. They were then purchased by the Spanish ambassador, and by him taken to Spain, where they adorned the palace of the Duke of Alva. From a descendant of this duke they were purchased, a few years ago, by Mr. Tupper, our consul in Spain, and brought to this country. They were afterwards exhibited at the Egyptian Hall, then sold to a foreigner, and sent abroad, and then again sent back to England for exhibition about the year 1838. Six tapestries form the remaining portion of this set. Since then we have heard nothing more concerning them, except a series of observations made by Professor Faraday on the power of light in restoring the brilliancy of some of the colours, which had become faded by a long exclusion from light.

Such, then, has been the eventful history of these unequalled cartoons and the tapestries made from them. M. Jubinal, in a beautiful work published at Paris, called 'Les Anciennes Tapisseries Historiées,' has given representations of some of the most celebrated tapestries on the Continent, from which it is observable that allegorical and historical subjects, generally complimentary to the person for whom the tapestry was made, prevailed more than any others.*

Hosiery.

Articles of hosiery differ from those commonly woven at the loom in being very much more elastic. Whether we regard the "lower-hosen" or the "trauses" of early times, or the stockings and gloves of the present, we shall find that the close fitting of the garment has always been regarded as essential; and this close fitting cannot well be ensured unless the material possesses much more elasticity than is generally possessed by woven cloth.

In the cuts of costume given in an earlier part of this chapter, indications of the hosiery of past times may be detected; and a few others are given in Figs. 555 to 558. In Fig. 555, for instance, are shown the Anglo-Saxon stockings or hose, reaching half way up the thigh, and bound round from the knee downwards with fillets of cloth. Fig. 557 represents three specimens, taken from monumental effigies, of hose made in the fourteenth century. Fig. 556 shows the close-fitting hose, or "trausses," of Chaucer's time, in which it was customary for one leg to be of one pattern or colour, and the other of another. Fig. 558 gives us a sort of buttoned-up hosiery, made in Edward IV.'s time. As to gloves, we have evidence (Fig. 559) that those made in former times greatly exceeded in elegance those to which we are accustomed in the present day.

In making hosiery of worsted, cotton, or silk, a machine called the "stocking-frame" is employed. This is a very complex piece of mechanism, so contrived that a continuous thread is made to loop around itself, and form a kind of chain or lattice-work. The process resembles neither common weaving nor net-making, but approaches more nearly to the latter than to the former. From the nature of the plexus produced, the material is capable of yielding in every direction, a property without which a well-fitting stocking could not be drawn over the foot. The closeness of the texture produced depends upon the material. Silk hosiery, made principally in and near Derby, is comparatively fine. Cotton hosiery, made in and near Nottingham, is coarser; while worsted hosiery, the staple manufacture of Leicester, is the coarsest of the three. The "frame-work knitters," as the stocking-makers are generally called, purchase their yarn from the spinners, and make it up into stockings, or stocking-pieces. Gloves, if made of the same material, are generally produced at a similar kind of machine, since they, as well as stockings, require to be elastic and yielding. Those made of leather belong to a different branch of trade.

Patterns for Weaving, Printing, and Embroidering.

The production of the patterns of the decorative portions of the clothing arts is the employment of a distinct class of persons, who are, or ought to be, educated with this view. Their art rests on different grounds, and is developed by different means from those to which the actual workman has recourse. The ornamental grouping of objects, and the combination of colours which they present, are the result of such taste as the designer may happen to possess: the mode of applying the pattern in practice is the point to which the workman directs his ingenuity. It is true that the workman is better qualified for his business if he has the taste of the artist as well as the manipulative skill of the mechanic; but the two qualifications are not the less distinct in their origin and character.

Calico-printing may illustrate one department of this designing. In every such establishment there is a room, or series of rooms, in which draughtsmen are occupied in sketching and painting patterns for the printers: a constant influx of novelty in pattern is required, and hence new ones are daily introduced. The designer has to endeavour to produce a pattern which will please the public, and, at the same time, one that will be practically efficient; for it is often found that a pattern which looks well on paper fails when transferred to cloth, from the different power of the two materials to develop the colours employed. The drawings are each about four inches square, and fully coloured. When completed it is examined in various ways, to see whether it will probably pay for the expense of the engraving. The designer has his taste or opinion, the proprietor has his, and the many-headed public have theirs; and it therefore by no means follows that all may agree. When a design is completed an inquiry comes whether it will "print" well, that is, whether it will appear well on cotton; and, if this point is satisfactorily settled, then comes the more difficult inquiry—whether it will catch the good opinion of the public. So severe are these two tests, that it was stated, about seven years ago, in evidence before a Committee of the House of Commons on the Arts of Design, that only one design in about five or six is accepted for engraving, all the rest being laid aside; and that of those engraved not more than one in five are decidedly successful in hitting public taste, the rest being comparatively unsuccessful. If this be the average state of the case, then only one pattern out of twenty or thirty drawn is satisfactory for the object in view.

A question here at once arises—why cannot the designers and the public agree as to beauty of design? This question opens up the whole subject of the principles of taste—principles which are still far from being settled. Fashion, novelty, and accident have very much to do with the favour which may be bestowed on any particular design; yet it can hardly be doubted that there are principles governing our notions of beauty in form and colour, however imperfectly they may be as yet developed. In a paper in the 'Art Union,' No. 62, on the application of the arts of design to calico-printing, attention is drawn to the fact that good designs cannot be produced unless the draughtsman has studied natural objects; since, whatever diversity of taste may exist as to beauty of form and colour, an imitation, more or less close, of the products of nature around us is almost universally acceptable. "We have before us," says the writer, "patterns of flowers, in which the leaves belong to one order of plants, the petals to another, and the stalk to a third different from either; we have birds depicted as far removed from possible existence as any of the monsters of heraldry; we have fanciful forms, and combinations of form, which set all powers of description, or even comprehension, at defiance; and we have blendings of colour as discordant with harmony as the thumpings of an infant on a pianoforte." The idea is further developed in the following remarks:—"In all natural objects there is an adaptation of the parts to each other; so that from the fragment of a bone an anatomist could give a pretty accurate account of the animal; and a botanist, from a single leaf, stem, or petal, would make a fair guess at the nature of the plant. This harmony of adaptation is one of the greatest elements of natural beauty, and it is displayed in the most minute and trifling particular: in the way the stem bends or stands erect, in the drooping or expansion of the flower, in the fold and position of every leaf, there are essential characteristics which cannot be disregarded without a sacrifice of natural beauty. Now we have seen designers copying flowers, not in the field or garden, but from cut specimens lying on their table. In such a state they copy an unnatural effect: the harmonies of the flower, and therefore its beauties, are thrown into distortion:—

> 'It lies uprooted from its genial bed,
> A lovely ruin, now defaced and dead.'

Another error is made when designers copy horticultural instead of botanical specimens. Most of what are deemed prize flowers are forced and unnatural monsters: they gratify curiosity, and not taste. Beds of double dahlias, prize tulips, and heavy hyacinths soon pall upon the eye; and pictures of them, even to unartistic eyes, are heavy, constrained, and clumsy. We have before us a tulip-pattern which is nothing better than a gorgeous absurdity; while another, which is but a simple sprig of fuchsia, is full of beauty and elegance, because it is true to nature."

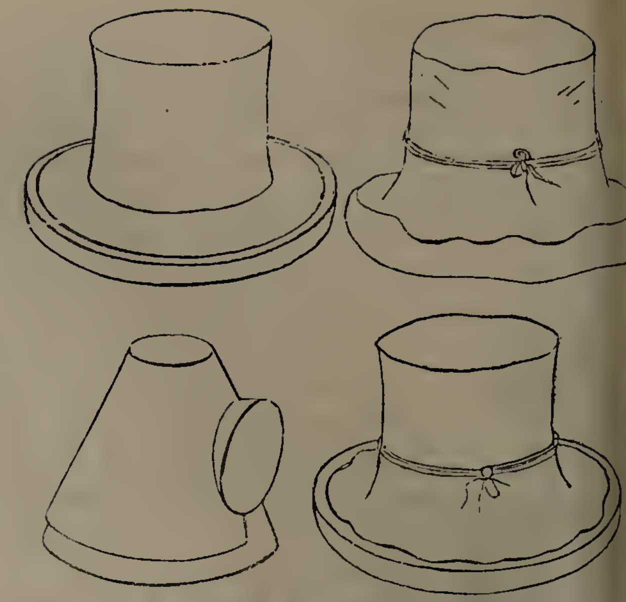
It would undoubtedly be a good feature if the arts of design were sufficiently cultivated for the designer and the purchaser to agree as to what is beautiful, and what is not; for, as it is, much money and time are spent unprofitably, the successful bearing so small a ratio to the unsuccessful patterns. Half a million designs for calico-printing are said to be produced yearly at Manchester, the expense of which is from a halfpenny to three farthings on each yard of cloth printed. Two steps have been taken within the last few years to improve this department of art; viz., the establishment of "Copyright of Designs," and the establishment of "Schools of Design." Until within a recent period a calico-printer, when he had procured a successful pattern or style, could never depend on having it long to himself; for others would take a specimen of the cloth, and have a plate or block engraved from it, thereby avoiding the expense of original designing. Some parties proceeded so unworthily and unfairly as to obtain nearly the whole of their patterns by this indirect method. To remedy in some measure the evil, Parliament had before given a protective copyright on the design for three months; but this was, in 1842, extended, for "garment prints," to nine months, and to "furniture-prints," or chintz, to three years. Under the operation of this latter Act each design is entered in a book kept by a registrar appointed by the Board of Trade.

As to the Schools of Design, these are the results of an attempt made by Government to improve the artistic skill of the workmen of this country. Schools are established at Somerset House, and branch schools at Manchester, Nottingham, the Potteries, Birmingham, and elsewhere; and at these schools arrangements are made for teaching the arts of design, under certain regulations, to persons who are likely to apply the skill thus obtained. Patterns for woven and printed goods, pottery and porcelain, manufactures in metal, and other such productions, are drawn; and the study of natural objects and of simple forms is attended to as a preliminary. It is an important matter in a national point of view; for there seems to be a pretty general impression that the English exhibit less taste in their inventions and designs than the French, arising from a more careful education of workpeople in the latter country than in England.

Patterns or designs must obviously have some relation to the mode in which they are produced in practice. Thus the Anglo-Saxons in their manuscripts often had initial letters (Figs. 560, 562, 563) involving a good deal of scroll-work, but the filling-up was seldom in good taste. From weaving or embroidering the pattern must often be made subservient to the manner in which the threads interlace one among another. In "Berlin-work," and other kinds where the embroidery thread takes up the woven thread in definite order, the pattern is necessarily rather a system of squares than of curves; and patterns may then assume some such forms as Figs. 561 and 565: they are, in fact, a kind of thread-mosaic, and differ but little in principle from tesselated pavements. There is still some difference of opinion as to whether such mosaic patterns as those just alluded to, or curves and scrolls such as those in Figs. 564 and 566, are best adapted for Berlin-work; but there can be no difference respecting the great su-

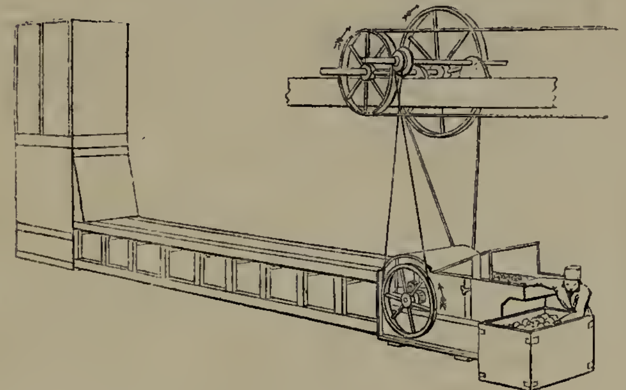
* A frontispiece to this volume will present a coloured Fac-simile of a remarkable Tapestry, after a design by Raffaelle, which has been recently brought to England.

571.—Canadian Voyageurs, connected with the Fur-trade.



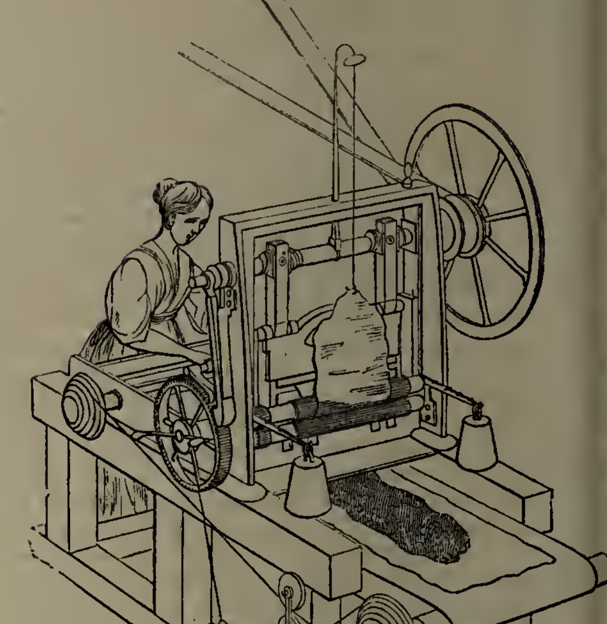
578.—Successive Forms of Hats and Bonnets.

574.—"Bowing" Fur and Wool for Hats.



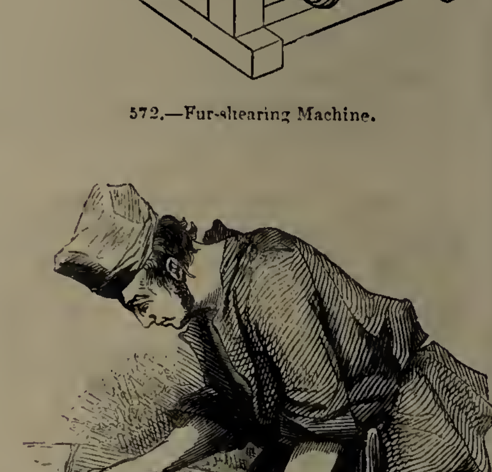
573.—Fur-blowing Machine.

576.—First form of a Beaver Hat.

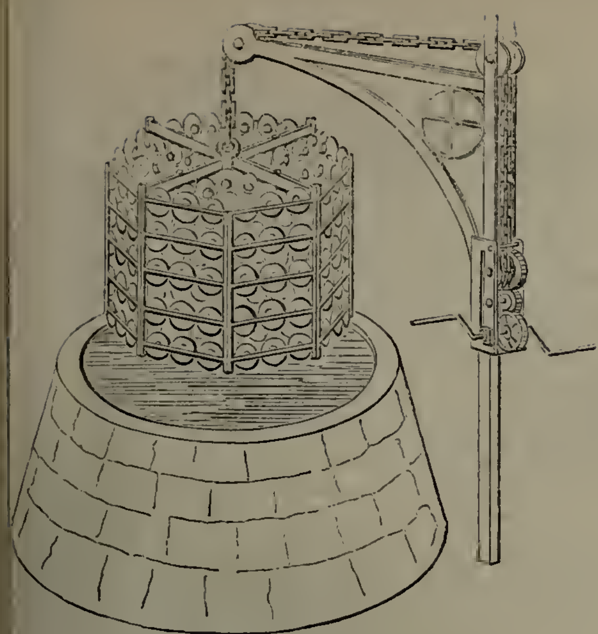


572.—Fur-shearing Machine.

575.—Hatters' "Kettle," several Stages of Hat-making.

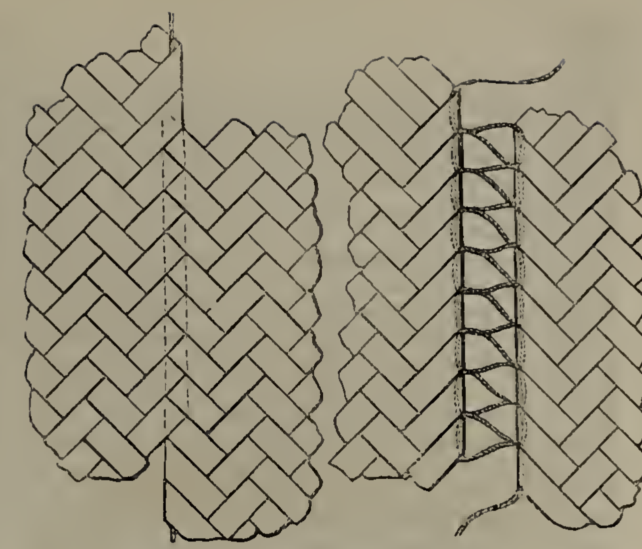


577.—Hat-making.

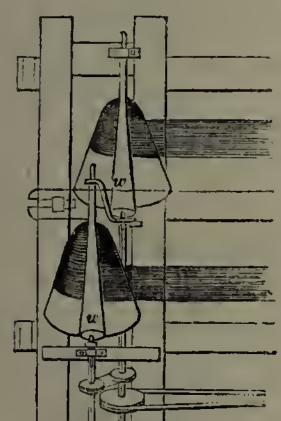


580.—Cage and Cauldron for dyeing Hats.

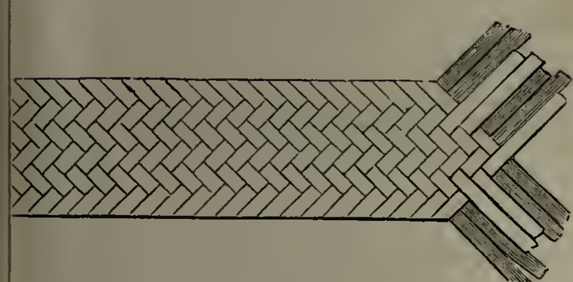
579.—Hat-making.



585.—Straw-plait.

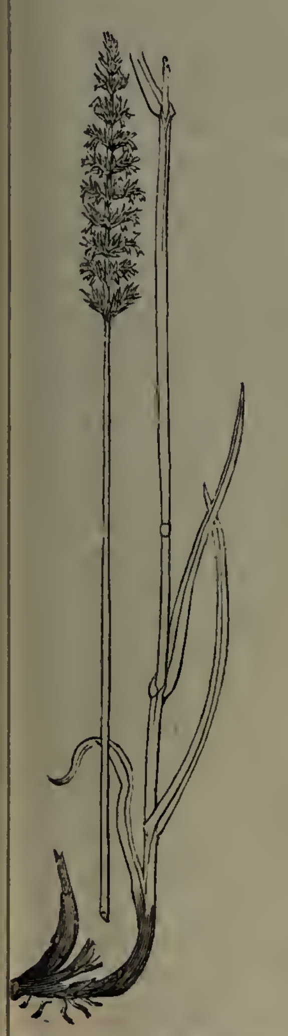


581.—Hat-felting Machine.

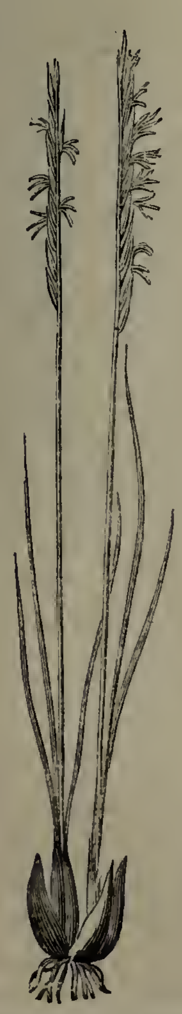


584.—Straw-plait.

586.—Animals yielding the original "Chamois" Leather.



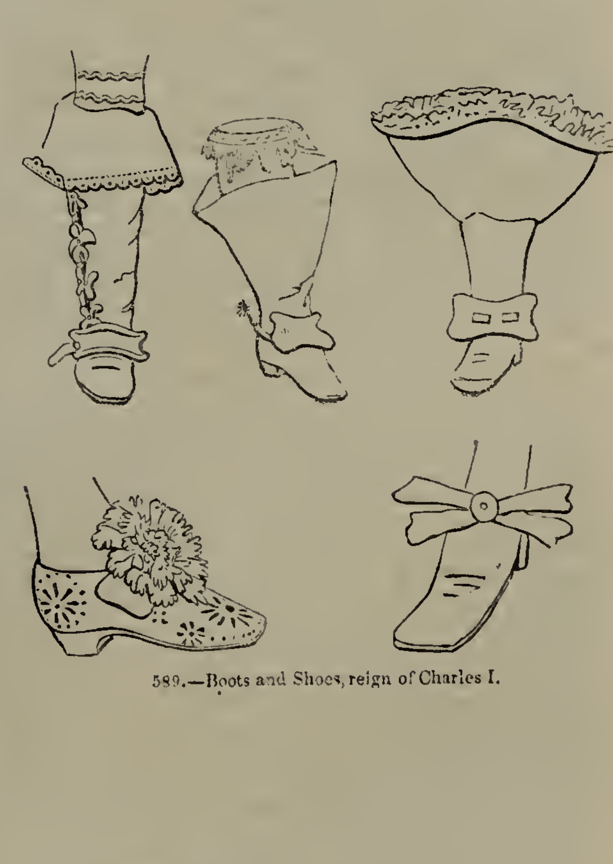
582.—Crested Dog's-tail Grass; used for Straw-plait.



583.—Common Mat-Grass; used for Straw-plait

587.—Roman Sandals and Shoe.

588.—Boots, reign of Henry VI.



589.—Boots and Shoes, reign of Charles I.

periority of any of these to the old "sampler" patterns of past times in England. Respecting the origin of the Berlin wool patterns, Miss Lambert gives the following details:—"About the year 1805 a Mr. Phillipson published some patterns, which, being badly executed and devoid of taste, did not meet with the encouragement he expected. In 1810 Madame Wittich—a lady of great taste, and an accomplished needlewoman, justly appreciating the advantages the art would derive from such designs, and anxious that this species of amusement for ladies should be more widely spread—prevailed upon her husband, a printseller of note at Berlin, to undertake the publication of a series of these patterns, which he did, got up in so superior a manner that many of the first patterns which were issued from his establishment are now in as much demand as those more recently published: in fact we very much doubt whether any since published by other houses have ever equalled, either in design or colouring, the earlier productions of M. Wittich. The designer and engraver of these patterns are of course paid as *artists*, in proportion to their talents; the cost of the first coloured design, or print paper, varying from three to thirty or forty guineas; but in some instances, as in the large pattern of Bolton Abbey, the Garden of Boccaccio, &c., it is considerably more. The colouring affords employment both for men, women, and children: a dozen, or half dozen copies are given to each person at a time, with the original design as a guide. An industrious man seldom earns more than one thaler, or three shillings, per day; the children from six to eight silver groschen, or from sixpence to tenpence English."

Whatever difference of opinion may exist as to the establishment of a standard of taste, in design and decorative patterns, or in the means of cultivating this taste by education, it is found by experience that there are certain national differences which are carefully attended to by manufacturers. For example, there is an extensive and celebrated manufactory of pocket-handkerchiefs at Glasgow, where the "bandanas" and other varieties are printed, and whence exports are largely made to almost every part of the globe. It is found that, in order to meet the wishes of the various purchasers, a few broad lines of distinction are to be observed. The patterns of handkerchiefs for the home-market scarcely admit of description; they consist of curves, zigzags, stripes, spots, and other devices which, when combined skilfully as to colour, are often pleasing to the eye, but have no definite meaning, and represent no particular object. Handkerchiefs for the Chinese market, on the contrary, must have a minute and exact delineation of birds, flowers, or some other natural objects, in order to meet the taste of the purchasers. For South America a gorgeous combination of the most brilliant colours is required, with very little attention to the design or objects represented. For Germany a totally different combination is necessary: here complete pictures are copied, with no attempt at finery of colours, but great attention to correctness of drawing. The pictures of Overbeck, Cornelius, and others of their painters, and some of those of Landseer and other artists in this country, are sought for as the patterns of handkerchiefs by our intellectual neighbours of Germany.

HATS: THEIR MATERIALS AND MANUFACTURE.

The reader has by this time had abundant means of observing how extensive, and how minutely ramified, are the arts relating to the manufacture of clothing. Taste, and mechanical ingenuity, and chemical research; capital, energy, industry, skill; commerce, diplomacy, legislation, national revenues—all take part so intimately in the various arrangements relating to these matters, that we cannot fail to recognise their importance. There are even yet other departments which call for notice before this chapter can be completed; but these we may limit to two—viz. *hats* and *shoes*.

The Fashions of Hats.

Nothing can be more fantastic than the varying fashions which have been given to head-coverings in different ages and countries. The turban of the East is perhaps the most rational and picturesque of all; for it really *does* cover the head (which is more than can be said of a modern English hat), and is at the same time susceptible of an elegant arrangement. Much less seemly, though perhaps not less convenient, is the strange head-covering of the Bedouin Arabs, which we hardly know whether to term a cap, a bonnet, or a hat. The high black Persian cap is totally different from both the others; and the hats and caps of the Chinese are not less distinctive in their character. The close-fitting skull-cap of the Greeks, the furred square cap of the Russian, the elegant hat and feathers of the Spaniard, are all as distinct from each other as from those already noticed.

In our own country the hats have not suffered fewer changes than in other places. The modern black beaver hat is the last, and perhaps one of the most inelegant and unmeaning of a long series of fashions. Why the head should be covered by a black cylinder terminated at the lower edge by a spout, it would perhaps be difficult to say; assuredly the shape of the head and the shape of a hat have very little in common; and it may be ranked among the minor miseries of everyday life, that a hat is not comfortable until it is nearly worn out. We do not mean to imply that previous fashions have been uniformly preferable to the present; but they certainly were so in many reigns. If we may take Stubs (a writer formerly quoted) as a correct chronicler of the things of his day, we must infer that hats were of a very varied character in the time of Elizabeth. He says, in his 'Anatomy of Abuses,' "Sometimes they use them sharp on the crown, peaking up like the spear or shaft of a steeple, standing a quarter of a yard above the crown of their heads, some more, some less, as please the fancies of their inconstant minds. Some others are flat and broad on the crown, like the battlements of a house. Another sort have round crowns, sometimes with one kind of band, sometimes with another, now white, now black, now russet, now red, now green, now yellow: now this, now that, never content with one colour or fashion two days to an end. And thus in vanity they spend the Lord's treasure, consuming their golden years and silver days in wickedness and sin. And as the fashions be rare and strange, so is the stuff whereof their hats be made divers also; for some are of silk, some of velvet, some of taffetie, some of sarsenet, some of wool; and, which is more curious, some of a certain kind of fine hair; these they call 'bever hattes,' of twenty, thirty, or forty shillings price, fetched from beyond the seas, from whence a great sort of other vanities do come beside."

The "bever hattes," which seem to have newly come into use in the time of Stubs, are those to which attention is more particularly directed in the present day, and to which our brief notice may chiefly relate.

The Materials for Hats.

All the usual English "beaver" hats (or such as are so called) are made from two classes of materials—*fur* and *wool*. In every hat, except the commonest "felt" hat, there are two distinct parts, the *body* and the *covering*, and these are always made of different materials. For the best beaver hats the body or main substance is made of fine wool and coarse fur, while the covering is of fine fur. For commoner hats the body is made wholly or mostly of wool, and the covering consists of some inferior kind of fur. According to the price at which the hat is to be sold, so is the quality of the materials used in making it. The cheapest beaver hats contain no beaver fur whatever, other and cheaper kinds of fur being employed instead of it.

The beaver, the coypus, the musquash, the hare, and the rabbit, are the animals whose fur is most generally employed in the making of hats. In most fur-bearing animals (Figs. 567, 568, 569) the hair or fur with which the body is covered is provided with little serrations or teeth (Fig. 570); and these teeth, as in the case of the fibres of wool, enable the hairs to felt or interlock one among another, thereby dispensing with any necessity for weaving.

The coypus, one of the animals which at the present day yields a large portion of the fur employed for hats, is a small South American animal. Soon after the commencement of the present century, the high price of beaver-fur led manufacturers to seek for some substitute. One pound weight of beaver-fur had gradually risen in value from one guinea to about four guineas, on account of the increasing scarcity of these animals. Under such circumstances, the hat-manufacturers were glad to commence the use of *neutria* fur (the name given to the fur of the coypus); and in many recent years as much as one million of these skins have been imported in twelve months.

Another animal, the musquash, or musk-rat, which yields fur fit for hatters, is a native of South America; it is about the size of a common rabbit, and is covered with two kinds of fur or hair having different degrees of fineness.

It is the beaver, however, which is peculiarly connected with the manufacture of English hats; so much so, indeed, as to have given a general name to such hats, even when there is no beaver or fur in them. Many marvellous tales have been told concerning the habits and almost human proceedings of the beaver; but these have been stripped of a good deal of exaggeration by more recent writers, although sufficient still remains to excite our admiration. The beaver, when in captivity, or unable to develope its natural powers, is rather a stupid animal; but, when free to follow the instincts of its nature, it shows remarkable ingenuity in forming its habitation. It seeks a spot where there is a sufficient depth of water to prevent frost from reaching the bottom, and it constructs a hut in which to pass the winter. It builds a dam to regulate the height of the water, and adopts a number of singular precautions to avoid capture.

Capture, however, does take place; for the ingenuity of the American Indians is more than a match for that of the beavers; and the skins, stripped from the animals and dried, are sold to the agents of the Hudson's Bay Company, and by them sent to England. This traffic is one of the most remarkable anywhere presented. There are, in the vast plains of North America, Indian hunters and half-breed trappers, whose business is to capture the animals by gins, traps, snares, or any means which their ingenuity may suggest. So long has this system been carried on, that all the fur-bearing animals near the inhabited districts have long since been exterminated: the hunters and trappers have had to go further and further into the heart of the continent, until at length the distance from the place of capture to the place of shipment to England has occasionally exceeded three thousand miles. The mode of conducting this trade is very remarkable. The Hudson's Bay Company have *depôts* in Canada and various parts of North America, and employ boatmen to carry provisions, stores, clothing, &c., up the rivers to the interior country, and to return with cargoes of furs; the boatmen and the hunters meeting at some intermediate spot.

About twenty years ago Captain Basil Hall, being in America, sketched the portraits of three of the hardy "voyageurs" engaged in this trade from Canada to the interior (Fig. 571). They were mostly of French origin, descended from the French who first colonized Canada. Until the year 1821 there were two powerful fur companies—the "North-West" and the "Hudson's Bay"—which maintained a strong competition against each other; but, by the coalescence of these two, there is now one vast district open to the fur-hunters in common from Canada to the Frozen Ocean, and from the Atlantic to the Pacific. To show the distances which the agents of the Company travel, it may be mentioned that there are forts or establishments at certain stages inwards, where the agents meet and transact their business; and that these forts, on one route alone, are thus placed:—Fort William, at the extremity of Lake Superior in Canada, is about twelve hundred miles from Montreal, the chief fur-trade station in that district. From Fort William to Fort Cumberland is more than a thousand miles; from thence, past Fort Chipewayan to Fort Resolution, is eleven hundred miles; and from thence, past Forts Simpson and Norman to Fort Good Hope, is nine hundred miles; so that the distance from Montreal to Fort Good Hope is more than four thousand miles.

The gradual extermination of the fur-bearing animals, and the establishment of steam navigation on the great lakes of Canada, are every year effecting changes in the mode of managing the fur-trade; but at the time when the "North-West" Company was in its full vigour, the Canadian voyageurs formed perhaps one of the most characteristic features of the system. Goods of all descriptions were sent out from England, and made up into garments and other useful forms in Montreal; the voyageurs in light canoes made of birch-bark were two months in conveying these stores up to Fort William, passing rapids (Moore's 'Canadian Boat-song' relates to this employment), portages, lakes, and obstacles which nothing but the most undaunted resolution and good humour could contend against; at Fort William they rested for a few weeks, and from thence brought back a whole year's cargo of furs, which other agents of the Company had brought from the interior country to Fort William. In these voyages the boatmen found their French vivacity invaluable to them, for they sang away wearisomeness, instead of sinking under it. The steersman of each boat or "batteau" was accustomed to sing a song, with a regular chorus, in which all the rest joined, keeping time with their oars. Washington Irving, in his 'Astoria,' says:—"The Canadian waters are vocal with these little French *chansons*, that have been echoed from mouth to mouth, and transmitted from father to son, from the earliest days of the colony; and it has a pleasing effect in a still, golden, summer evening, to see a batteau gliding across the bosom of a lake, and dipping its oars to the cadence of these quaint old ditties, or sweeping along, in full chorus, on a bright sunny morning, down the transparent current of one of the Canadian rivers."

The present critical state of affairs between England and the United States, respecting the Oregon territory, is in some degree connected with the fur-trade; for all that has been yet done to make that territory worth contending for has been effected by the fur companies, some under the influence of England, and some under that of the United States. Washington Irving's remarkable work, from which we have just taken an extract, has for its object an account of a bold and singular enterprise, undertaken by a wealthy American gentleman named Astor, for the establishment of a fur-trade colony to be named after himself, on the Oregon or Columbia river; and though the enterprise failed, as far as regards the interests of Mr. Astor, enough was done to complicate the question as to the respective rights of England and America to the territory.

Whatever may have been the changes in the internal management of the fur-trade, it is enough for our present purpose to bear in mind that the furs employed in

hat-making are brought chiefly from America; that native hunters capture the animals, and sell or barter the skins to the agents of the companies; that the furs are shipped from Montreal, Oregon, Hudson's Bay, and South America, for England; that the Hudson's Bay Company have two great sales annually, at Easter and Michaelmas, at their house in Fenchurch-street; that the furs mostly employed for cloaks and other garments are purchased by the furriers, and by foreigners for the continental market; that the beaver furs (amounting to sixty or eighty thousand annually) are bought by the chief hat-manufacturers, as are likewise neutria and some other furs; and that all these matters must have been concluded before the English hat-maker can commence his labours.

The Processes of the Hat-manufacture.

When the furs come into the hands of the hatter, the hair, which is the valuable part, is attached to the pelt or skin of the animal, and a separation of the two must be effected before the manufacture can commence. This is done by a machine acting in a singular manner (Fig. 572). There is a long sharp blade, having a vertical motion like a chopper; and the pelt being passed between two rollers, is placed in such a position that the blade can cut or shave the fur from the skin without cutting the skin itself. Before this is done the pelt has been cleaned with soap and water, and the coarse outer hairs pulled off by women, who use a sort of knife for this purpose; so that it is only the finer hairs which are taken off by the machine. The skin, when deprived of its covering of hair, is sold to make "size" or weak glue.

The fur taken off by the machine is not all of equal quality; some of the fibres are coarser than others, and a very curious means is adopted for effecting a separation between the coarse and the fine. There is a square hollow box or trunk (Fig. 573), forty or fifty feet long, having at one end a fan or wheel capable of revolving two thousand times in a minute. The loose fur is taken out of a chest by a man, and laid upon a kind of platform where the current excited by the rapid revolution of the fan can act upon it; this current is so violent that it blows the fur through the long trunk. But all the fur is not equally acted on: the coarse fibres, being comparatively heavy, fall before they reach the other end, and are deposited on the level bottom of the trunk; while the finer fibres, less able to contend against the powerful draught, are blown into an upright receptacle at the other end of the machine. By this means the fur is separated into qualities fitted for different purposes.

The fibrous materials are next disentangled and opened by the process of "bowing." The foundation of a hat is not made of the loose fibres of beaver fur, but of wool and rabbit fur; and these require the operation of bowing. The bower has a staff made of ash, with a cord of catgut stretched from end to end, and the bow thus formed is suspended by a string from the ceiling (Fig. 574). The wool and hair are laid out flat on a bench, and the workman, plucking the cord by means of a piece of wood held in his right hand, causes it to vibrate against and among the wool, thereby working the fibrous mass into a light flocculent layer.

The quantity of material for the "body" of a good beaver hat is about two ounces and a half, of which two-thirds is generally rabbit's hair. This quantity is separated into two parcels, each of which is pressed with a light wicker frame until the individual fibres, on account of the serration at their edges, cling slightly together. A piece of oiled leather, called a "hardening-skin," is also pressed and worked over the fibrous surface, to ensure still more this coherence. Each of these masses is of a triangular shape, and by placing one on another, with a piece of paper between them, they are, by a peculiar mode of joining or rubbing them together at the edges, formed into a kind of conical cap, having just coherence enough to maintain its form.

Then ensue the very singular operations conducted around the hatter's "kettle" (Fig. 575). This kettle is a cauldron, heated by a fire underneath, and provided at the edge with six or eight sloping boards, which serve as work-benches for an equal number of men. At these sloping benches the forthcoming hat is "wetted," "rolled," "pressed," "ruffed," and "blocked." The conical cap, measuring probably twenty inches in each direction, is dipped into a hot acid liquor, and then subjected for two hours to a most severe ordeal; it is beaten, pressed, rubbed, rolled and unrolled, twisted and turned about in every direction, wetted again and again; and such a constant agitation of the fibres kept up, that they become inextricably "felted," or interlocked one among another. A piece of paper is kept within side, to prevent the opposite sides of the cap from felting together; and the result of the process is, that after the shrinkage occasioned by the felting, the cap presents itself under the form of Fig. 576; drab-coloured, flexible in substance, and measuring fourteen or fifteen inches each way.

This cap is dried in a stove-heated room, and is next rendered waterproof by a coating of gum, resin, and spirit. It then receives the outer covering of beaver fur. This fur is placed out in a layer, and pressed till it slightly coheres into a thin film. The cap is dipped into the acid liquor, and the film of beaver is laid carefully on it (Fig. 577). The two together are wrapped in a woollen cloth, and are rubbed and rolled for a further space of two hours, until the "covering" has become felted very intimately with the "body." The beaver hairs enter between the fibres of the cap, and it is a part of the workman's care to see that they do so just sufficient to hold lightly.

The conical cap is next made to assume the more familiar form of a hat. The workman by pulling, and pressing, and rubbing, produces a flat top instead of a peak to the cap, and this enables him to place the cap down over a block of wood (Fig. 579), to which he attaches it by means of a piece of string. The hat (for it now begins to assume something of that form) is dried in a stove-room, the block still remaining in it. When dried, it passes into the hands of the "shearer," who raises and opens the nap by a sort of comb, and cuts the fibres by means of a pair of shears: the shearing being more or less deep according as the hat is to be "short-napped" or "long napped." A great many hats are then dyed together; each hat being put upon a block, and the block being attached to a large open cage (Fig. 580). The cage dips into a cauldron containing a hot-dye liquor of logwood and other ingredients: and by repeated emersions and immersions, with an alternate action of the dye-liquor and the atmospheric air, the hats become thoroughly dyed. When dyed, they are steeped, washed, and dried.

While under the dyeing process, the hat is in a somewhat shapeless state; and to give to it the proper shape is the object of the next process. The material is softened by steam, and is pressed and rubbed over and around an oval block, until it conforms to the shape of the block, and presents a smooth flat brim. Fig. 578 shows three successive stages of a hat under this operation, and also a beaver bonnet on the block which helps to give it shape.

The hat is then provided with the lining, the leather, the binding, the band, &c., and is lastly shaped according to the fashion of the day by means of heated irons.

Attempts have been occasionally made to effect the felting process for beaver hats by machinery. In Fig. 581, for instance, there is shown a contrivance for working hat-bodies by coiling loose filaments of wool into the form of conical caps, round wooden blocks, and causing them to cross and intersect each other, so as to mat or felt together when rubbed or pressed. The attempts, however, do not seem to have been attended with much success.

Silk Hats.

The very curious train of operations which we have just glanced at apply only to beaver hats, or at least to hats whose "body" is formed of felt, and whose "covering" is of fur. Silk hats are a wholly different product, and are made by men who occupy a lower position as hat-makers than those employed upon beaver hats.

In making the body of a silk hat a piece of stiffened cambric, or more generally of willow, is shaped round, and cemented at the edges by a resinous varnish; the brim being made by a piece of material thicker than the other part. When shaped, the hat is coated with a resinous waterproof composition. The covering is a species of silk plush, woven in the manufacturing districts for this purpose; it is cut up into pieces, and sewn by women into a kind of hood or envelope, something like the shape of a hat. The body receives a coating of a peculiar kind of varnish; and when this is dry, the hood is laid on. A heated iron, applied at the surface of the plush, softens the varnish beneath, and causes the plush to adhere to the body of the hat. The most difficult part of this process consists in hiding the joint where the two edges of the plush meet; this joint is not sewn, but the edges are made to come exactly together, and the loose silken shag smoothed over the junction. In every silk hat this junction can be seen, generally a little oblique to render it less visible. The superior class of silk hats, called "Paris hats," are not made in Paris, but the silk plush is woven there, and is of superior quality to that made in England.

Straw-Plait Manufacture.

There is one material for hats and bonnets, so far peculiar in its character, that it gives employment to women rather than to men, in its manufacture: this is *straw-plait*.

This department of industry is separated into two distinct branches, according as English or Italian straw is employed. In the former case, the straw is grown, cut, bleached, and plaited, pretty nearly in one district: in the latter case, the straw is both grown and plaited in Italy, and is merely made up into hats and bonnets after importation into this country. The straw-plait district of England comprises the counties of Bedford, Hertford, Buckingham, Cambridge, Suffolk, and Essex. In the time of the war, when the importation of straw hats from Leghorn was interrupted, great encouragement was given to the English manufacture, and an additional number of persons embarked in the employment; this increase of numbers led to increase of competition, and the competition led to improvements in the growth, splitting, and bleaching of the straw. But on the conclusion of the war, the Leghorn hats, being superior in fineness, colour, and durability to those of England, regained their ascendency.

The straw-plait manufacture of Tuscany gives employment to a large number of females. M. Chateauvieux, in a series of letters published some years ago, speaks of the following scene which met his view while travelling through Tuscany:—"The road I travelled was bordered on both sides by village houses, whose distance from each other did not exceed one hundred paces. They are all built of brick; and the architect has bestowed upon them a justness of proportion and an elegance of form unknown in our climate. They consist of a single pavilion, that has often but one door and two windows in front. These houses are always situated along the road, and separated from it by a terrace and supporting wall, some feet in breadth. Upon this wall usually stand several vases of the antique shape, containing aloe plants, flowers, and young orange-trees. The house itself is entirely covered by vine branches; so that, during summer, one knows not whether they are so many pavilions of verdure, or dwellings prepared for winter. In front of these houses, swarms of young country girls are seen, dressed in white linen, with corsets of silk, and straw hats adorned with feathers, inclining to one side of the head. They are constantly occupied in braiding the fine plait, the treasure of this valley, from which the straw-hats of Florence are made." He then proceeds to describe the manner in which they proceed with their work, and concludes in the following strain:—"Such, Sir, are the female peasants of the Vale of the Arno, whose grace and beauty are so celebrated by travellers; whose language Alfieri went there to study; and who seem, in fact, born to embellish the arts, and to furnish them models. They are shepherdesses of Arcadia, but they are not peasants; they possess only the health and freedom from care of that state, and never know its anxieties, its sun-burnings, and its fatigues."

But this sentimental picture of artless simplicity and happiness has been sadly pulled to pieces by writers of a more practical kind. Instead of "pavilions," we hear of "smoky huts;" and instead of the "freedom from care, and anxiety, and sun-burnings, and fatigue," we hear, from Mr. M'Culloch, that "the dust and perspiration in summer, and the benumbed fingers of the workwomen in winter, when they are compelled to keep within their smoky huts, plaiting the cold and wet straw, are equally injurious to the colour of the hats, which no bleaching can improve."

The kind of straw cultivated in Tuscany for plaiting is the *triticum turgidum*, a variety of bearded wheat. Where the wheat is grown purposely for the straw, as it is in many places, the seed is thickly sown on a poor strong soil on the bank of the river Arno; and when the crop has attained the height of a few inches, it is mown near the ground, as a mode of subduing the weakness of the plant, and rendering the after stems more slender. This mowing is done a second, a third, and even a fourth time, according to circumstances. When the stems are sufficiently fine they are allowed to grow; and after the bloom is over, but while the grain is still very milky, the plants are pulled up, and exposed to the sun on the sandy shore of the river, care being taken to water them from time to time. When the straw has attained the proper colour, a careful selection is made of it, and it is divided into several qualities according to the size and excellence of the straw. The part between the first and the third joints is employed for common plait, only a few inches below the ear being appropriated to the finer kinds. After a little preparation, the straws are formed into a plait of thirteen, and these plaits are connected at the edges so as to form a continuous circular flat disc, called a "flat;" the fineness being determined by the number of rows of plaits from the centre to the edge.

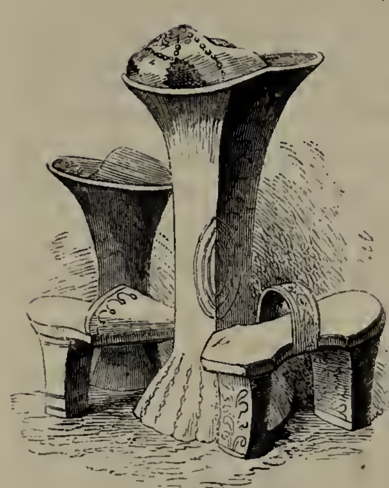
In England several species of the grasses have been found more or less adapted for this purpose, among which are the two shown in Figs. 582, 583. The Society of Arts has shown a praiseworthy desire to advance as much as possible this branch of art, deeming it one well fitted for the cottagers in agricultural districts. It has been observed on this point that "there is perhaps no manufacture more deserving of encouragement and sympathy than that of straw-plait, as it is quite independent of machinery, and is a domestic and healthful employment, affording subsistence to great numbers of the families of agricultural labourers."

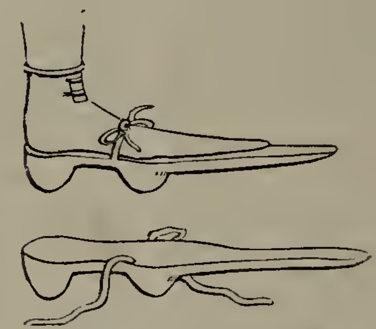
The mode of interlacing many straws among each other, to produce a plait, can be pretty well understood by dissecting a specimen; but the following will give an idea of the Italian mode of making a plait from thirteen straws, such as is sketched in Fig. 584. After the straws have been cut and sorted, they are tied together at the ends into a group, six being inclined a little towards the left, and seven towards the right. The outermost straw on the right hand is turned down by the finger and thumb of the right


596.—Leather Manufactory, Bermondsey.


593.—Chinese Men's Shoes.

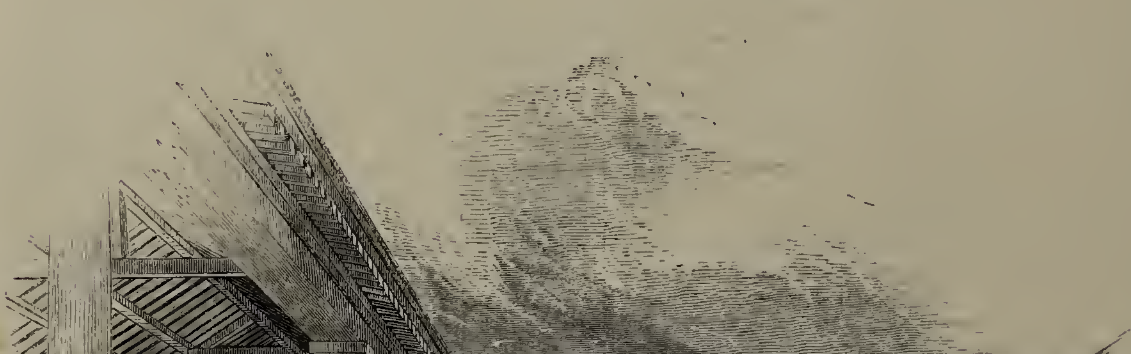

594.—Chinese Women's Shoes.


592.—Choppines, or High Shoes.


590.—Shoe and Pattens, reign of Richard II.


591.—High-heeled Italian Shoe.


598.—Leathersellers' Hall, London.


597.—Leather and Skin Market, Bermondsey.

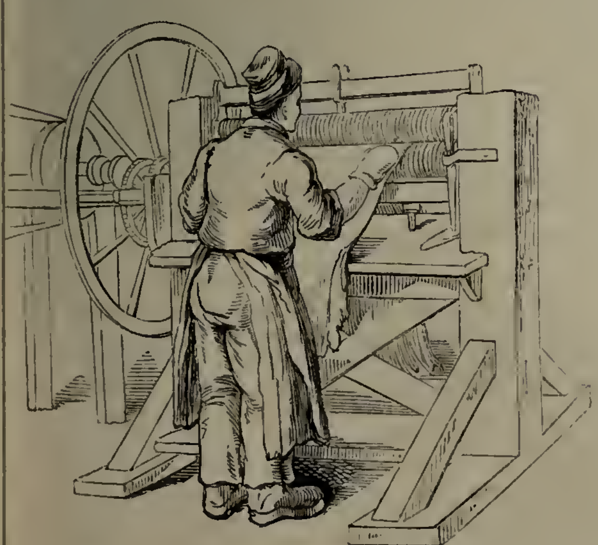

595.—Mangrove; the bark used in tanning Leather.

600.—Steeping Goat-Skins.

602.—Tanning Leather with Sumach.

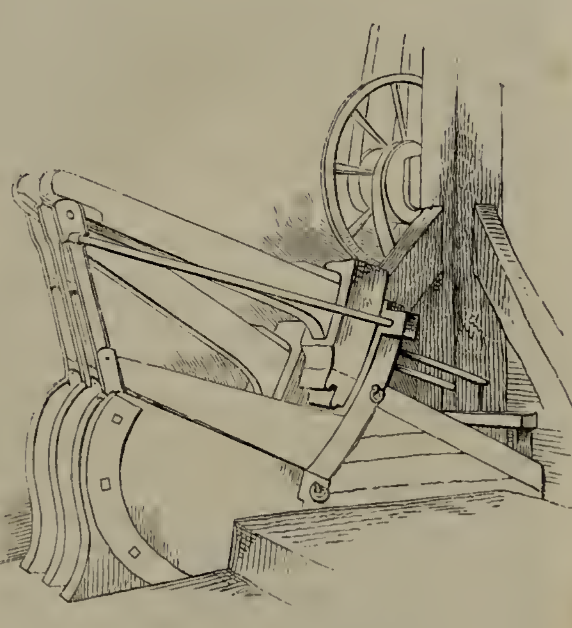
601.—Unhairing a Goat-skin.

599.—Peeling Oak-bark for tanning Leather.



603.—Leather-splitting Machine.

604.—"Tawing" Kid Leather.



605.—Oil-Leather Fulling-stocks.

hand, and passed alternately under two, over two, and under two of the other six straws in the same parcel. There will then be seven straws on the left, and six on the right; and the next stage consists in passing the outermost on the left hand under two, over two, and under two. By this change there are again seven straws on the right, and six on the left, as at first; and the outermost on that side is again passed under two, over two, and under two. This repetition goes on alternately until the piece is completed; every straw becoming in turn the outermost one, and made to interlace among the others. The appearance which they then present is such as that shown in Fig. 584. In Fig. 585 are given two representations of the mode of connecting two plaits together, edge to edge, by means of thread, so as to present the appearance of a uniform wide plait: the right hand side shows the intersection of the thread, and the left hand the closed juncture of the two plaits.

LEATHER: ITS VARIETIES AND MANUFACTURE.

The last great class of clothing-materials which, in this chapter, we shall deem it necessary to consider, is *Leather*, a material differing wholly from any yet noticed.

The Varieties of Leather.

Among the animals whose skins or hides are applied to this purpose many diversities are presented. Thickness or solidity is generally the most prominent point of difference, but not the only one: for many skins present a softness and pliability independent of their thickness. The hides of the ox, the calf, and the horse, and of many other thick-skinned animals in foreign countries, have a degree of thickness which qualifies them to be used for boots and shoes, for harness, for straps, and other purposes; and these undergo the process of *tanning*, by means of oak-bark, or other materials having similar qualities. The skins of the goat and the sheep are thinner; they do not require the process of tanning in the same manner, or to the same degree as the thicker hides; and the leather made from them is very varied in its character. For instance *Morocco* leather, for coach-linings, chair-covers, bookbinding, &c., is made of goat-skin; an imitative morocco is made of sheep-skin, treated much in the same way as goat-skin; *roan*, prepared from sheep-skin, is used for women's shoes, slippers, and common bookbinding; and skiver, also from sheep-skin, and a still commoner sort of leather, is employed for hat-linings, pocket-books, work-boxes, toys, and other cheap purposes. There is another class of leathers, in which alum is the chief agent in the preparation; these are generally the skins of the kid, the sheep, and the lamb; and the leather produced is principally employed for gloves and ladies' shoes, having the general appellation of "kid." Lastly, there is a variety of leather in which oil is the chief preparing material; the skins of the sheep, the buck, and the doe are so treated; and the leather so prepared is used for riding-gloves, breeches, gaiters, and the thin soft material known as "wash-leather."

The animals whence all these varieties of leather are obtained are generally reared for other objects than the skin which they yield. The ox and the calf, the two greatest sources for leather in this country, do not, so far as we are aware, undergo any particular routine of treatment for the benefit of the leather, the flesh being by much the more valuable product; and the same may be said of the sheep and the lamb. But with respect to the animals which are not tamely reared the same cannot be said. The goat and the chamois, and other animals shot or captured in various countries, have seldom a value in respect to their flesh equal to that of the animals above-named, while their hides or skins are always valuable for converting into leather. The hunting of the chamois among the rocks and glaciers of the Alps (Fig. 586), one of the most exciting, but dangerous employments anywhere known, is in general carried on rather for the sake of the wild enthusiasm which accompanies it than for the value of the product: yet it is these animals which yield the real chamois leather, an imitation only of which is known among ourselves.

Feet-coverings, as illustrating the use of Leather.

Beyond all doubt the manufacture of boots and shoes is the most important purpose to which leather is applied; and it is curious to observe the variations which have occurred in this respect in different countries and ages.

The shoes mentioned in the earlier books of Scripture are not accompanied by any particular mention of materials, but it appears probable that many different materials were used; for the early Egyptians made shoes and sandals of papyrus, linen, and even wood. The Roman shoes, or sandals, were originally made of rude untanned leather, or rather hide; but better and more finished materials were afterwards adopted. There were two kinds of shoe worn by the Romans, the *calceus* and the *solea* (Fig. 587), of which the former nearly covered the foot, something like a shoe, while the latter covered only the sole of the foot, and was fastened above with leathern thongs. In the time of the Roman empire the shoes of the higher classes were beautifully decorated, and indeed all classes bestowed as much cost on their shoes as their means would permit.

With respect to our own country, many changes, both of material and of form, have taken place. The Anglo-Saxons wore all the three varieties—boots, shoes, and slippers, or coverings which bear some resemblance to these. In the manuscripts and illuminations still preserved having relation to that period the shoe is mostly represented black, with an opening down the instep, secured by a thong; generally the shoe seems to have been of leather, but among great personages it was often highly costly in its material and decorations. About the twelfth century many of the shoes worn were bandaged across the foot, somewhat in the manner of sandals; cloth boots, fretted and embroidered with gold, were also worn. By about the time of Richard II. the outrageously peaked shoes and boots (Fig. 588) came into fashion, extending, in some instances, to such a degree of absurdity that the peak of the boot was fastened up to the knee. There were also pattens worn at the same time which partook, in great measure, of these lengthy proportions (Fig. 590). These boots and shoes appear to have been pretty uniformly made of leather; for there was a proclamation issued in the reign of Edward IV. to the effect, that any cobler or shoemaker who should make peaks to the shoes and boots exceeding two inches in length should pay a fine of twenty shillings, of which part was to be paid to the Cordwainers' Company of London. Driven from one extremity, fashion plunged into another; and the shoes and boots thereafter became so wide that an enactment was made ordering that no shoes and boots should be *more than six inches* in width. The shoes were often slashed and decorated in the time of Henry VIII. In relation to the reign of Elizabeth, Stubs says:—"They have corked shoes, puisnets, pantoffles, and slippers; some of them of black velvet, some of white, some of green, and some of yellow; some of Spanish leather, and some of English, stitched with silk, and embroidered with gold and silver all over the foot; with other gewgaws innumerable."

In the time of Charles I. roses of large size were worn on the shoes: and, to protect them from mud in the streets, pantoffles, or slippers, were worn over them. Next came into use Spanish leather boots (Fig. 589), having very large tops, ruffled with lace or lawn, and sometimes tied at the sides. The lower part of the same cut shows the rose, and also the shoe-tie which afterwards superseded it. High heels then came in; a fashion which attained a ridiculous excess in Italy by the use of "choppines," or "chapeneys," of which three or four varieties are seen in Fig. 592. Coryat, in his 'Crudities,' thus spoke of them:—"There is one thing used of the Venetian women, and some others dwelling in the cities and towns subject to the signiory of Venice, that is not to be observed (I think) amongst any other women in Christendom, which is so common in Venice that no woman whatsoever goeth without it, either in her house or abroad, —a thing made of wood, and covered with leather of sundry colours, some with white, some red, some yellow. It is called a *chapiney*, which they wear under their shoes. Many of them are curiously painted. Some also of them I have seen fairly gilt. So uncomely a thing (in my opinion), that it is pity this foolish custom is not clean banished and exterminated out of the city. There are many of these chapineys of a great height, even half-a-yard high, which maketh many of their women that are very short seem much taller than the tallest women we have in England. Also I have heard it observed among them, that by how much the nobler a woman is, by so much the higher are her chapineys. All their gentlewomen, and most of their wives and widows that are of any wealth, are assisted and supported either by men or women when they walk abroad, to the end they may not fall. They are borne up most commonly by the left arm, otherwise they might quickly take a fall." Evelyn, too, speaking of the same custom, says:—"The noblemen walk with their ladies stalking on 'choppines;' these are high-heeled shoes, particularly affected by these proud dames, or, as some say, invented to keep them at home, it being very difficult to walk with them; whence one being asked how he liked the Venetian dames, replied that they were 'Mezzo carno, mezzo ligno' (half flesh, half wood), and that he would have none of them. When they walk abroad they set their hands on the heads of two matron-like servants, or old women, to support them." Even at the present day shoes with extravagantly high heels (Fig. 591) are occasionally seen in Italy.

From the time of Elizabeth downwards there has been but little exception to the general rule of boots and shoes being made of leather, whatever may have been the shape, or the mode of fastening.

The shoes of the Chinese (Figs. 593, 594) are remarkable in two respects—the material of those for the men, and the size of those for the women. Mr. Davis says that in winter persons of some rank wear "boots of cloth, satin, or velvet, with the usual thick white sole, which is kept clean by *whiting* instead of *blacking*, in the usual style of contrariety to our customs. The thick soles of their boots and shoes, in all probability, arose from the circumstance of their not possessing such a substance as well-tanned leather, a thinner layer of which is sufficient to exclude the wet. The shoes made for Europeans at Canton are perfectly useless in rainy weather, and spoiled on the very first wetting." With respect to the shoes of the Chinese ladies, every reader is aware that, by an odious custom of the country, cramped and distorted feet are deemed "genteel," and that the natural growth is checked from infancy, as a means of attaining this object.

Materials employed in Tanning Leather.

Without dwelling farther on the vagaries of fashion, we may proceed to speak of the mode of preparing leather; and first, of the materials employed for effecting it.

In almost all astringent vegetables there is a peculiar substance or principle called *tannin;* and this tannin, when separated by steeping, and applied to raw hides, acts upon, or combines with, these in such a way as to convert them into leather. Hence the leather manufacturers, aided by scientific chemists, have had to discover what vegetable substance will most profitably yield this agent.

The mangrove (Fig. 595) is one of the plants from whence a tanning ingredient has been occasionally obtained. The acacia catechu is another; and the tanning material is produced from it in the following manner:—As soon as the trees are felled, all the exterior white wood is carefully cut away; the interior coloured wood is then cut into slips, and placed in unglazed pots. The vessel is filled up with water and boiled until the water is half evaporated; the decoction, without straining, is poured into a shallow eathen vessel, and further reduced two-thirds by boiling. It is then set in a cool place for one day, and afterwards evaporated by the heat of the sun, being stirred several times during that process. When it is reduced to a considerable thickness, it is spread upon a mat or cloth which has been previously covered with the ashes of cow-dung. The mass is divided with a string into quadrangular pieces, which are completely dried by being turned frequently in the sun, and are then fit for sale.

Oak-bark is, however, beyond any other substance the one which is most extensively used in this country in tanning. Indeed at one time it was almost the only material; and when it became very high priced, the Society of Arts offered premiums for the discovery of any new substitute. This encouragement, together with the discoveries of modern science in vegetable chemistry, and a more extended knowledge of the proceedings in other countries, has greatly extended the list of substances fitted to be employed in tanning. Oak, sawdust, oak-leaves, pulverized heath, oak-galls, birch-bark, myrtle-leaves, the bark of the willow, dried leaves of the wild laurel, tormentil root, mangrove root—all are used in different countries for this purpose. The bark of the alder, the larch, and many other trees, is similarly employed.

But notwithstanding the progress of discoveries, oak-bark continues to be the most extensively employed material for this purpose, at least in England. The peeling of the bark from the trees is a country employment (Fig. 599), carried on in the following manner:—When an oak-tree has been felled for the sake of its timber, and while yet lying on the ground, it is surrounded by a group of women, who take the bark from it. Each woman is furnished with a light short-handled mallet, made of hard wood, about eight or nine inches long, three inches square at the face, and sharpened at the other end like a wedge. A straight incision is made in the uppermost side of the tree from end to end by means of the sharp end of the mallet; while another instrument, called a "barking-bill," is used to cut the bark across the tree into lengths of two or three feet; and a sort of shovel, called a "peeling-iron," is next employed to peel off the bark, by being inserted between the bark and the wood. The trunk having been thus stripped of its bark, the larger branches are similarly treated. The bark, when peeled, is carefully dried for two or three weeks, then piled in stacks eight or nine feet square by fifteen in height, and finally sold to the tanners.

The Processes of Tanning Leather.

A very large proportion of all the leather prepared in England is tanned and dressed in Bermondsey, where many establishments exist similar to that sketched in Fig. 596, exhibiting an open court, a series of tanks, pits, or sunk cisterns in the court, and a range of buildings on two or more sides of it. There is also in Bermondsey a leather and skin market (Fig. 597), where undressed skins are sold in an open market or under sheds, and finished leather in a range of warehouses bounding the court; the tanners being the purchasers of the raw hides in the one case, and the sellers

of the tanned hides in the other. Leather-sellers' Hall (Fig. 598) is a memento rather of what used formerly to be the internal arrangements of the trade, than of arrangements still existing; since the practical commerce of London has long since ceased to be guided by the (nominally) trading companies, excepting in a very few instances.

The two terms "tanning" and "leather-dressing" are not of the same import. When the thicker hides, such as those of the ox, the horse, the calf, and the dog, are prepared for making shoes and boots, the preparatory processes are included in the general name of "tanning;" but when the thinner skins, such as those of the goat, the kid, the sheep, and the lamb, are prepared into leather for gloves and other light purposes, the preparation is called "leather-dressing." We will begin, then, with tanning.

When the hide of a slaughtered ox has been taken from the animal it is sold to the tanner with the horns attached; and these he sells, after separation from the hide, to comb-makers, lantern-makers, and other artificers. The hide is then stretched out over a convex beam, called a "horse," and is scraped with a long knife to remove any small adherent bits of flesh, &c., from the inner surface; at the same time all the fleshy portion of the skin itself is also removed, so as to leave the cutis or true skin, which is the part to be converted into leather. The removal of the hair from the outer surface is the next point. This is done either by steeping the hide for several days in lime-water, by which means the bulbous roots of the hairs become so far loosened as to be easily pulled out; or it is placed in a close chamber, where the hairs loosen by a kind of natural putrefaction which ensues. When by either of these means (generally the former) the hairs are sufficiently loosened, the hide is again placed on the beam, and scraped on the outer side, so as to remove all the hairs.

When the hide is thus brought to a tolerably clean state, it is steeped for some days in an acid solution, so calculated as to open the pores of the hide, soften it, and prepare it for the reception of the tanning material. Most of these materials, when soaked in water, yield a yellowish brown liquid; and this liquid is found to corrugate or shrivel living skin when applied to it, and to convert dead skin into leather; but a very long-continued action is necessary for this change, and the arrangements of the tanners are made accordingly. Many attempts have been made within the last few years to shorten the duration of the tanning process, but it still remains one of a lingering character.

In every tannery are a number of square or circular pits, sunk in the ground wholly below the surface, and capable of containing liquid. In these pits the tanning ingredient, whether oak-bark or any other, is steeped with water, producing a dark-coloured liquor called technically "ooze." Among several pits, some contain ooze stronger than others, owing to some of the tanning property having been absorbed by hides previously steeped in it; and the hides are steeped first in the weaker ooze and then in stronger solutions one after another. Sometimes the hides are laid in the pit with bark strewed between them; and indeed there are many different ways of causing the tan to act upon the hides, but in all cases the time of actual immersion in the tan-pits is very great, sometimes amounting to as much as fifteen or eighteen months. All this time, the tanning ingredient is working its way slowly into the pores of the hide; and when it has reached the centre the tanning is completed. The gelatinous portion of the hide, when combined with tannin, produces a new compound or substance capable of resisting putrefaction, and this it is which constitutes the difference between hide or skin and leather.

When the tanning process is completed, the hide is hung up in an airy loft or drying-room, and during the process of drying it is compressed by beating, by pressure with a steel instrument, or by rolling. The very stout hides, such as those of the ox and the buffalo, are fitted for making the soles and heels of men's boots and shoes; while the thinner, such as those of the calf and the seal, and the thinnest among those of the horse and the cow, are employed in making the "upper leathers." The thin hides, although tanned with bark in the same manner as the thick ones, require a much less consumption of time in the process.

The thinner kinds of tanned leather, such as those just alluded to, require a further process before being fitted for use. They pass into the hands of the "currier," whose business is to give them a suppleness and yielding quality which they would not otherwise possess. For this purpose the tanned skin is moistened in water, and beaten with a wooden mace; it is afterwards placed on a sloping board, and scraped or shaved until any superfluous parts of the thickness are removed. After this the leather is again soaked in water, and rubbed on the outer side with pumice or gritstone. It is further rubbed very forcibly and for a considerable time with a hard piece of wood covered with grooves, the action of which is to give much suppleness to it. These processes of steeping, beating, scraping, and rubbing, are continued for a greater or less space of time, according to the quality of the leather; after which the blacking and polishing, if required, finish the routine.

The Russians prepare the hides of horses, mules, and asses in a way which requires no tanning. It is only a portion of the skin, on the back near the tail, which is selected for this purpose. This piece is soaked in water, scraped, and stretched on frames; while so stretched, soft small seeds, such as mustard seeds, are pressed into it; and it is dried with the seeds in it; the seeds are afterwards beaten out, and the skin then presents that pimpled graining which we recognise in "shagreen" leather. It is afterwards polished, soaked in a ley, and dyed of various colours. This shagreen, which is used as a covering for small cases and boxes, though extremely hard, is readily softened by water, and is in that state easily worked.

The Process of Leather-Dressing.

The skins which do not require a process of tanning with bark owe their transformation into leather mainly to one of three ingredients—*sumach*, *alum*, and *oil*.

Sumach is a yellowish material, obtained from the leaves and young branches of a plant called the *Rhus coriaria*, growing in Italy; it is a kind of tanning ingredient, though not applicable exactly in the same way as oak-bark. As before observed, goat and sheep skins are those which are principally treated with this material. In making morocco-leather from goat-skins, the skins, which are imported into this country from various parts of the world, are soaked in water, scraped on the fleshy side, soaked again for a longer period, and scraped on the outer side to remove the hairs. During these soakings the skins are taken repeatedly out of the pits by men (Fig. 600), whose feet and legs are covered with thick leather casings to keep them dry; and after lying for some time by the side of the pit, they are again immersed. The scraping or "unhairing" is affected in the manner shown in Fig. 601; and the hair so obtained is sold to the carpet manufacturer or to plasterers.

By the time that the scraping is finished, the lime from the lime-water has penetrated so far into the pores of the skin that the tanning ingredient could not find entrance, and the skin is therefore soaked in an alkaline solution to remove the lime. This done, and the skin being freed as much as possible from all impurities, each skin is sewn up by women into a bag, with the grain-side outwards and the flesh-side inwards, and having no opening except at one part. Several of these bags are thrown into a large shallow vessel (Fig. 602) containing a solution of sumach in water. Each bag is filled with sumach solution before being thrown into the vessel, and is tied in such a way as to enable it to float. The object of this curious arrangement is that both surfaces may be acted on at once. In the short space of three hours the sumach exerts its action completely through, and converts the skin into leather. Once or twice during the process the skins are taken out of the solution and laid on one another on a side bench for a short time. This done, the seams are opened, the sediment of the sumach removed from withinside, the skins are scraped and smoothed, and lastly hung up to dry.

In making morocco leather, which is known by its beautiful grain and pliability, the dyeing of the leather now takes place; this process being conducted very much in the same way as in the dyeing of cloth. When dyed, the leather is well rubbed to give it softness, first with a smooth substance, and then with a grooved piece of wood. This piece of wood is about the size of a lemon, and is made of very hard wood; the grooves are fine, and from the manner in which the workman rubs this ball forcibly over the leather, he produces those fine lines and wrinkles which distinguish morocco leather.

Sometimes sheep-skin is applied to purposes in which a smaller thickness would suffice. In such cases ingenuity has led to the construction of a machine (Fig. 603) which will separate a skin into two thicknesses with the utmost accuracy.

In those kinds of leather where alum is employed, the kid or lamb skins are soaked, scraped, limed, and unhaired, much in the same way as for other purposes; but after this, instead of being immersed in a solution of sumach, they are rotated rapidly in a barrel containing alum, salt, and yolk of egg. In a very short time the skins have imbibed these ingredients; and when dried, they are forcibly drawn over the edge of an upright plate (Fig. 604), a process (called "tawing") which imparts to the leather that delicate softness which distinguishes kid.

In preparing skins with oil, so as to produce "chamois"* leather, the processes of steeping, liming, scraping, &c., are adopted as usual, and the skins are often split by the machine, if thin or inferior "wash-leather" be required. But instead of being then exposed to the action of bark, or of sumach, or of alum, they are put into a heavy machine, called a fulling stock (Fig. 605), then sprinkled with oil, and beaten with heavy mallets, which work up and down in a kind of trough, until the oil is completely beaten into the pores of the leather.

The various kinds of leather, prepared in one or other of the ways thus described, pass into the hands of the thousands or tens of thousands of artisans who work them up into boots, shoes, gloves, saddles, harness, belts, whips, and a host of other articles, by processes of manufacture which, though interesting in themselves, do not call for particular detail in this place.

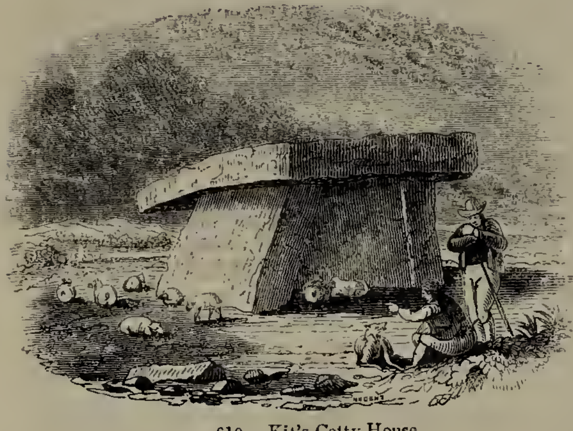
Here we draw to a conclusion this rather lengthy Chapter. The extensive range of subjects which it has presented, and the three hundred woodcuts by which it has been illustrated, will afford some idea of the vast, the complicated, the admirable, and in many respects the astonishing features presented by the Arts relating to Clothing. It is only a selection, here and there, from the vast storehouse which Nature's bounty and man's ingenuity have provided, that we could profess to give in such a work as this; and yet how wide is the range of thought which it may suggest! The observant skill of the naturalist, the experimental research of the chemist, the untiring inventive power of the machinist, the cartoons of the man of genius, and the designs of the man of taste—all have been brought into requisition in the carrying out of these Arts. And if we were to add that geographical discovery has been aided, that the surface of the earth has been enriched, that the properties of natural products have been developed to us, and that man himself has become more humanized, by the direct or indirect influence of these Arts, we should only say what might well be proved, if proof were necessary.

* Here, as in a former instance, we may remark on the number of ways adopted for spelling the same word:—Chamois, chammy, shammy, shammoy, shamoy—all have been used by different writers.

606.—South American Indian Hut.

607.—New Zealand Hut and Garden Fence.

608.—New Zealand Village.



610.—Kit's Cotty House.

611.—Cabin of the Ancient Latins.

612.—Irish Stone Cabin.

609.—Huts in the Island of Ceylon.

613.—Irish Mud Cabin.

614.—Canadian Log-house.

616.—Arab Huts at Busheir.

615.—Canadian Log-Village.

621.—Front of a Private House, Cairo.

617.—Hindoo House, Calcutta

619.—House top Terraces.

618.—Chinese Garden-Pavilion.

620.—Eastern Chamber on a Wall.

CHAPTER IV.

THE ARTS IN REFERENCE TO DWELLINGS.

The mode in which change or progress has been made in respect to garments has been pretty much the same as in reference to a sheltering roof. In both, the rude man has but few wants, and supplies those few quickly and readily; in both, the civilized man wants more and more the further advanced he becomes. The skin of a captured animal for a dress, and a hollow tree or rock for a dwelling, are about equal in simplicity; a "court-dress," and the mansion of the person who wears the court-dress, are perhaps not far from equality in the opposite extreme. And indeed this is the only way in which advance can be made in such matters; for until that which has been deemed a *luxury* becomes looked upon as a *convenience*, or until the conveniences of life become *necessaries*, there is but little motive for invention and improvement.

Let us glance at a few of the more simple kinds of dwellings, as a means of comparing them with the houses which are familiar to every-day observation, and of seeing in what manner the decorative arts have been developed by changes in taste.

THE HOUSES OF VARIOUS COUNTRIES.

The use of bricks as a material for building houses is very little known, except in countries pretty well advanced in civilization. Rudely hewn stones, wicker-work, open framework of wood, dried mud, logs roughly put together—these are the prevailing materials among nations where the arts of life are but slightly developed. It might be said in objection to this, that the ancient Egyptians and Babylonians were accustomed to use bricks in building; but this is no objection at all; for those two countries were, relatively to others by which they were surrounded, in an advanced state of civilization, and exhibited in their highest form the various arts then known.

The Huts of rude Nations.

Many of the tribes of South America, in the vast plains which intervene between La Plata and the Orinoco, reside in huts of the most simple construction (Fig. 606). Such a hut is merely a roof of broad leaves, supported upon poles arranged in three rows. The poles of the middle row are longer than those of the two outer rows, to allow for the pitch of the roof. The hut is completely open to the air on all sides; the effects of bad weather being in some degree provided against by mats hung up at the sides. The Indians sleep in long hammocks of net-work, suspended under the sloping roof. The implements of their occupations, such as fishing, hunting, &c., are hung up around the hut. Azara, describing the huts of the Pampas Indians, says:—"They drive into the ground three stakes, as big as a man's wrist, about four feet distance from each other. The middle stake is about six feet high, the others are shorter, and each is terminated at the top by a fork; about twelve feet from these, three other stakes are driven, of the same form and height. They then place horizontally on the forks three long sticks or reeds, on which they stretch the skins of horses. When the weather is cold, they add also horses' skins to the sides."

The New Zealanders, who occupy a much more intellectual position than most whom we are in the habit of calling barbarous tribes, make for themselves huts far superior to those we have just noticed. The peaked roof (Fig. 607) and the garden-fence are much more closely wattled: and in some of the New Zealand villages (Fig. 608) there is an approach to the cottage form of construction; large twigs covered with rushes being, however, the chief, if not the only material employed. In Ceylon, on the contrary, earth is partially employed in the construction of the huts (Fig. 609), with a thatching of grass or other material to keep out the weather.

The custom of placing a few stones rudely together to form a shelter, was often followed among the early nations. Thus, the druidical structure sketched in Fig. 610, and the cabins in which the ancient Latins of Italy were wont to dwell (Fig. 611), are abundantly simple in their structure. It is true that the former of these, the strangely named "Kit's Coty House," still existing in Kent, is supposed to have been a sort of sacrificial altar, or in some way or other connected with the religious ceremonies of the ancient Britons; still it offers materials for conjecture as to the general character of the dwellings constructed by that people.

There is something painful in the idea of including any part of our own country among the "rude nations," in respect to the kind of dwellings which the people are forced to adopt; yet the present state of things in Ireland scarcely leaves an alternative. The Isle of Lewis, one of the Hebrides, and many of the districts in the heart of Ireland, are decidedly below New Zealand in regard to the comforts of the dwellings for the poorer classes. In the 'Statistical Account of Scotland' it is stated that the poorer huts of Lewis accommodate cattle as well as human beings under the same roof. "The roofs have no eaves. The thatch in general is made of stubble or potato-stalks, which are spread on the scanty wooden roof, and bound by leather or rope straws, which again are at each side of the roof fastened by stones called anchors, resting on the top of the broad wall. From the slightness of the wooden rafters, much straw or stubble cannot be laid for thatch, but just sufficient to exclude the daylight. The thatch is not expected at first to keep out the rain until it is impregnated with soot; but the inmates keep plenty of peats on the fire; the interior is soon filled with smoke; the smoke and increasing heat repel the rain, for a great proportion of what falls on the roof is returned to the atmosphere by evaporation. These houses, after a smart shower, appear like so many salt-pans or brew-houses in operation."

In Ireland the state of the poor cabins has never failed to excite the astonishment of travellers who have had the means of comparing them with the poorer class of dwellings in other countries. A window or a chimney is scarcely thought of in such cabins: the light is admitted at the door, and the smoke is left to find its way out by the same channel, unless indeed a hole be made in the thatched roof for this purpose. The door is often merely a piece of matted straw. The thatch of the roof is blackened with smoke and cobwebs, and is often quite rotten through with damp. The floor is almost invariably the natural earth of the ground, worn into hollows, which become the receptacles of pools of water from the rain trickling through the roof. A stone cabin (Fig. 612), formed of a few stones heaped rudely one on another, with an ill-shaped opening for an entrance, seems bad enough; but many of the cabins are formed of less substantial materials, being simply built up of dried mud (Fig. 613). In some cases the cabin, only just visible above the surface of the ground, is merely a gravel-pit or a wide ditch, the sides of which form the walls, and the ends are blocked up with sods or earth; the same material being also used to form a roof. Near some of the bogs the cabins are made entirely of turf: a few sticks are made fast at the angles with ropes of sedge, and sods of turf are placed over these as a roof; neither door nor window nor chimney being provided—nothing but a mere opening as an entrance.

These deplorable dwellings give an air of inexpressible desolation to the districts where they are clustered. The Commissioners on the Irish Poor Law Enquiry give abundant evidence as to the misery of those hovels. In many of them the roof affords such insufficient protection from the wet, that the inmates are often obliged to shift their beds to another corner of a cabin in the course of a rainy night. One of the witnesses examined stated that he found little more protection from rain within some of the cabins than if he had been standing in the open air. On the occasion of a cabin being erected, the floor is made by digging up the ground on which it is built, and then trampling it down to something like a level surface. To such an odd degree are hilarity and misery mixed together among the inmates of these cabins, that one of the witnesses stated it to be a custom to invite the neighbours to have a dance on the occasion, so that the trampling might be made a matter of pleasure as well as a matter of business; and that "many a match comes out of a thing of the sort." As to furniture, it corresponds with the hovel which contains it. A barrel, or a pail turned upside down, for a table; a few stools; a pot or two; some straw for a bed, and a few rags for a blanket—these are the prevailing articles of furniture.

No persons are better able to estimate correctly the *relative* misery of such dwellings, than travellers like M. Kohl; and his picture is sad enough. He says:—"I remember that I once pitied the poor Lithuanians in Livonia when I found them dwelling in houses merely formed of stumps of trees, the interstices filled up with moss. I pitied them, especially on account of the low entrances to their dwellings, and the smallness of the windows, and gladly should I have seen their chimney better arranged. I remember too what melancholy reflections rose in my mind when I beheld the simple, rude, and wretched arrangements of their household. Now, may God forgive me for my ignorance! I might have spared all this; for I did not know that it had pleased him to lay such privations and worse upon another people. After I had seen Ireland, I found that even the poorest among the Lithuanians, Esthonians, and Finlanders, live decently, and that in ninety-nine cases out of a hundred Paddy would be delighted if he could be housed, clothed, and fed as any of those people. Whoever has seen Ireland will no longer think any other part of Europe miserable; he will even consider the condition of savages preferable. A log-hut lined with moss—what a luxury! The Irishman's dwelling-place is usually built with mud and straw! one shovelful piled upon another, intermixed with a few rough stones picked up in the fields, till the walls are sufficiently high. A house regularly thatched or covered with brick would indeed be admirable: the Irishman often covers his with the turf taken from his bogs. Small windows filled up with panes of glass or half-transparent bladders, or talc, as here and there in Wallachia and some parts of Russia—such luxuries are unknown to an Irish peasant. Here most of the huts are without windows; one square hole in front serving at once for window, chimney, house-door, and stable-door, for light, smoke, men, and pigs to pass through." The fault in this description is, that M. Kohl represents as a general average that which is the lowest grade of all, thereby making matters rather worse than they really are.

The log-houses of Canada (Figs. 614, 615) are a very curious class of dwellings, deriving their general character from the circumstances of the country in which they are placed. When an emigrant or a settler wends his way towards the "bush" (as a forest district is familiarly called), there to seek a home, he has to cut down the trees to form a vacant space, and with the trees so levelled he builds a log-house. The felled trees are stripped of their principal branches, and are shaped into logs twelve or fifteen feet in length. The smaller branches and fragments are burned, and the stumps are left to rot in the ground. If the settler be of the very poorest class, he erects a mere "shanty;" if in better circumstances, he builds a "log-house" of more substantial character. A shanty is a kind of shed built with logs, the openings between the logs being filled up with moss or with mud, to keep out the rain; the roof is formed of split and hollowed logs placed side by side, and similarly stopped with moss or other material; sometimes one opening serves for door, window, and chimney; but generally a little more attention is paid to comfort.

In the regular log-houses, however, for the more respectable emigrants, a better system is adopted. There is a friendly feeling among the emigrants, which prompts them to assist each other; and when a log-house is to be built, all the neighbours join to form a "building-bee," that is, an association who will work together until the house is finished: it is a point of honour, arising out of mutual wants, to render some service or other on such an occasion. The authoress of the 'Backwoods of Canada,' detailing the circumstances under which her husband and herself were actually placed in respect to their own "building-bee," says:—"Sixteen of our neighbours cheerfully obeyed our summons; and though the day was far from favourable, so faithfully did our *hive* perform their tasks, that by night the outer walls were raised. The work went merrily on, with the aid of plenty of Canadian nectar (whiskey), the honey that our bees are solaced with. Some large joints of salt pork, a peck of potatoes, with a rice pudding, and a loaf as big as an enormous Cheshire cheese, formed the feast that was to regale them during the raising. This was spread out in the shanty, in a very rural style. In short, we laughed, and called it a 'pic-nic in the backwoods;' and, rude as was the fare, I can assure you great was the satisfaction expressed by all the guests of every degree, our

'bee' being considered as very well conducted. In spite of the difference of rank among those who assisted at the 'bee,' the greatest possible harmony prevailed, and the party separated well pleased with the day's work and entertainment. The following day I went to survey the newly raised edifice, but was sorely puzzled, as it presented very little appearance of a house. It was merely an oblong square of logs, raised one above another, with open spaces between every row of logs. The spaces for the doors and windows were not then chopped out, and the rafters were not up. In short, it looked a very queer sort of place, and I returned home a little disappointed, and wondering that my husband should be so well pleased with the progress that had been made. A day or two afterwards I again visited it. The sleepers were laid to support the floors, and the places for the windows and doors cut out of the solid timber, so that it had not quite so much the look of a birdcage as before."

The mode of making these log-houses is as follows. The logs are laid over each other horizontally, to form each of the four walls; and they are all so notched at the ends as to fit into each other, and form a junction at the corners of the house. The openings between the logs are closed up with moss. A few rafters are stretched across the top, over which is placed a layer of birch-bark, and above this a thatching of spruce branches or long grass: this thatching is kept down by poles and birch-withies, so as to form a very convenient roof. The chimney is a wooden framework, resting on a stone hearth at a small height from the ground; the framework extends upwards through the roof, and is lined with clay so as to resist fire. The flooring, the door, the window, the interior finishing of the walls—all depend on the means and ingenuity of the settler, and vary much in different instances.

The Houses of Eastern Countries.

The countries of Asia are not wholly without examples of hovels and huts of a very humble character: we allude not to the rude and black regions of Siberia, or to the plains of Tartary; but to the more southern countries, which we are in the habit of associating with the idea of Oriental luxury. The Arab huts at Busheir (Fig. 616) are very little indeed different from many which have before engaged our notice. Mr. Frazer, in his 'Journey to Kourdistan,' on one occasion sought shelter in a Kourdish cabin situated underground. After descending through an irregular passage, he found himself in a sort of little hole, scantily lighted by a small orifice in the roof, with a chimney in which was smothering a fire made of wet dung-cakes. "It seemed," he says, "to be the domicile of a favourite horse and a pet ewe: the latter we ousted; the former still retained its berth behind a sort of bar, so contrived as to prevent further intrusion on its part, and mark the boundary of our domain, where it chewed its hay—a very unoffending neighbour. After my eyes had become somewhat accustomed to the dark and smoky atmosphere, I left our den to peer about a little. In one neighbouring cavern were stabled a number of horses; in another were congregated a collection of most unlovely women, children, and sheep; from a third there was pouring forth a multitude of cows and year-olds that nearly upset me. There was not much pleasure in all this, so I returned to our room, where musnuds had been spread; but scarcely was I seated when in rushed a great he-goat, with a bound and a 'baa-a-a!' followed by his two wives, probably the rightful occupants of some corner usurped by us, who stopped short when he saw us, and seemed disposed to do battle for his privileges."

The character of Eastern houses of the better sort depends very much on the climate and habits of the people, and differs in different provinces. In some districts of India the houses are built of brick, and extend round the four sides of a quadrangle; the chapel of the Hindoo family occupies one of these four sides, while the private apartments fill the other three. During festivals or holidays an awning is extended over the whole court, beneath which the common people are admitted, those of superior rank occupying the verandahs. The dwellings of the middling classes are constructed in a similar style, but with different materials; the walls being of mud, the roofs of bamboo and thatch. The very poorest, in most parts of Bengal, have to content themselves with a damp hut consisting of but one room. In the Mysore territory the mud-houses of the poorer classes are of a better kind, owing to the clay of the district containing a good deal of decayed granite, which gives hardness to the material. In Malabar the huts consist of a circular mud wall covered with a long conical roof of thatch; each family has a hut for sleeping, another for cooking, and a third for a storehouse: wealthy men add to the number of huts which form their dwelling, but do not deviate much from the general style of construction. In other parts of the same district the houses are two stories in height, built with stone, and thatched with cocoa-nut leaves. In Marwar the villages have a remarkable appearance. Each group is surrounded by a circumvallation of thorns, which, with stacks of chaff rising abvoe it at intervals, gives it the appearance of a kind of fortification; the houses are often thatched with bulrushes. In districts which are liable to depredatory attacks the building arrangements are much more substantial; thus, among the Ghauts, every collection of houses is defended by a round fort, into which the inhabitants retire when attacked. In Guzerat the villages consist of thatched cottages built of mud, and a few brick houses with tiled roofs. Bishop Heber found a Hindoo farm, on the banks of the Ganges, to be thus constructed: in front was a small mud building with a thatched verandah looking towards the village, and behind was a court filled with cocoa-nut husks and a little rice-straw; in the centre of this was a round thatched building, raised on bamboos about a foot from the ground, so as to form a granary; round it were small mud cottages, each forming one apartment.

Benares is the most characteristic of all the Hindoo cities; and from the Bishop of Calcutta's description of the mansion of an opulent citizen, whom he visited at that place, we may obtain an idea of their general arrangement. The house was very irregular, built round a small court, two sides of which were taken up by the dwelling-house, the others by offices. The house was four lofty stories in height, with a tower over the gate of one story more. The front had small windows of various forms, some of them projecting in brackets and beautifully carved; while a great part of the wall itself was covered with carved patterns of sprigs, leaves, and flowers like an old-fashioned paper. The whole was built of stone, but painted deep red. There was an entrance-gateway, covered overhead by a groined arch; and on each side was a rich deeply carved recess to contain the household idols. From the inner court a narrow and deep flight of stone steps led up to the first story of the building. Fig. 617 will give an idea of the better kind of Hindoo houses at Calcutta.

Passing from India to China, we find, from the descriptions of Mr. Davis and other writers, that the general average of Chinese houses bear a good deal of resemblance to those in other Oriental countries; but that the large mansions are more fanciful in their construction and arrangements. In general the houses consist of a ground-floor, divided into several apartments within the dead wall that fronts the street, and lighted only by windows looking into the internal court-yard. The principal room, next to the entrance, is the reception and dining room; and within this are the private apartments, the doorways of which are screened by cotton or silk curtains. In the best houses there any seldom any stairs beyond the few stone steps by which they are raised above the general level of the ground. The stonework of the foundation is generally solid and handsome, and in the neighbourhood of Canton it consists of granite. The walls are of blue brick, frequently with an artificial facing or painting. The partition walls of the inner court are frequently broken into compartments, which are filled with an open work of green varnished tile or coarse porcelain. The roofs are covered with tiles whose transverse section is nearly semicircular; one range being laid with the concave side uppermost, and the edges of these being covered with another range having the convex side uppermost.

The general arrangement of a Chinese house is a good deal influenced by the circumstance whether it be situate in a town or in the open country. The estimation in which a mansion is held depends very much on the ground which it covers, and the number and size of the courts and buildings; but in towns, where land is more valuable, the houses and shops have generally a story above the ground-floor, and on the roof is often erected a wooden stage or platform, like the terraces of Eastern houses. The Chinese seem to feel much surprise at the loftiness of European houses, and have very little inclination to imitate this style of building.

Sir George Staunton visited one of the higher class of Chinese mansions, and has described it somewhat minutely. There was first, exterior to the whole, a brick wall, having a gateway opening from a narrow street. One side of this wall supported the upper ridge of roof, whose lower edges, resting upon an interior wall parallel to it, formed a long range of buildings divided into apartments for servants. The rest of the enclosure was subdivided into several quadrangular courts of different sizes. In each quadrangle were buildings upon platforms of granite, and surrounded by a colonnade, the columns being of wood, and having intercolumniations of painted carved-work. This colonnade served to support that part of the roof which projected beyond the wall-plate in a curve, turning up at the angles. The colonnades of this description were so numerous, that all the various parts of the building might be visited under cover. None of the buildings were above one story, except that which comprised the ladies' apartments during the residence of the owner. This building was situated in the inmost quadrangle; the front consisted of one long and lofty hall, with paper windows; and on the back of this hall was carried a gallery, at the height of about ten feet, which led to several small rooms, lighted only from the hall. The garden-pavilion sketched in Fig. 618 will give a good idea of the fanciful style of Chinese buildings.

In many of the countries which form the scene of Scripture narrative there are illustrations of the Eastern custom of making terraces on the house-tops (Fig. 619), where the inmates spend many hours in the cool of the day, and even occasionally sleep at night. The houses, in such cases, are generally built in narrow confined streets, into which fresh air can hardly enter, and it is only from the house-top terraces that a cheerful look-out can be obtained. The custom of building a chamber on or in a wall (Fig. 620) is another of those to which allusions are made in Scripture, and which travellers find to be still occasionally followed in the East.

Egypt, another country presenting the peculiar features of Oriental life and industry, is not wanting in interesting examples of the building arts. Of the Egyptian houses generally, both as to the materials and the mode of construction, Mr. Lane gives a very detailed account. In the private houses of Cairo the foundation walls, to the height of the first floor, are cased with a soft yellowish stone; the alternate courses of the front being sometimes coloured red and white, particularly in large houses. The superstructure, the front of which generally projects about two feet (Fig. 621), and is supported by corbels or piers, is of brick, and often plastered. The bricks so employed are burned, and are of a dull red colour; the mortar is a mixture of mud, lime, and ashes. The roof is flat, and is covered with plaster. The entrance-door is often ornamented in some such a way as the one sketched in Fig. 622, being fancifully coloured with red, white, and blue paint, and inscribed with some Mohammedan verse, or moral maxim, in the Arabic character. The poorer classes of houses, however, have unpainted doors, much less elegant in their appearance. An iron knocker, a wooden lock, and a stone door-step generally constitute part of the arrangements.

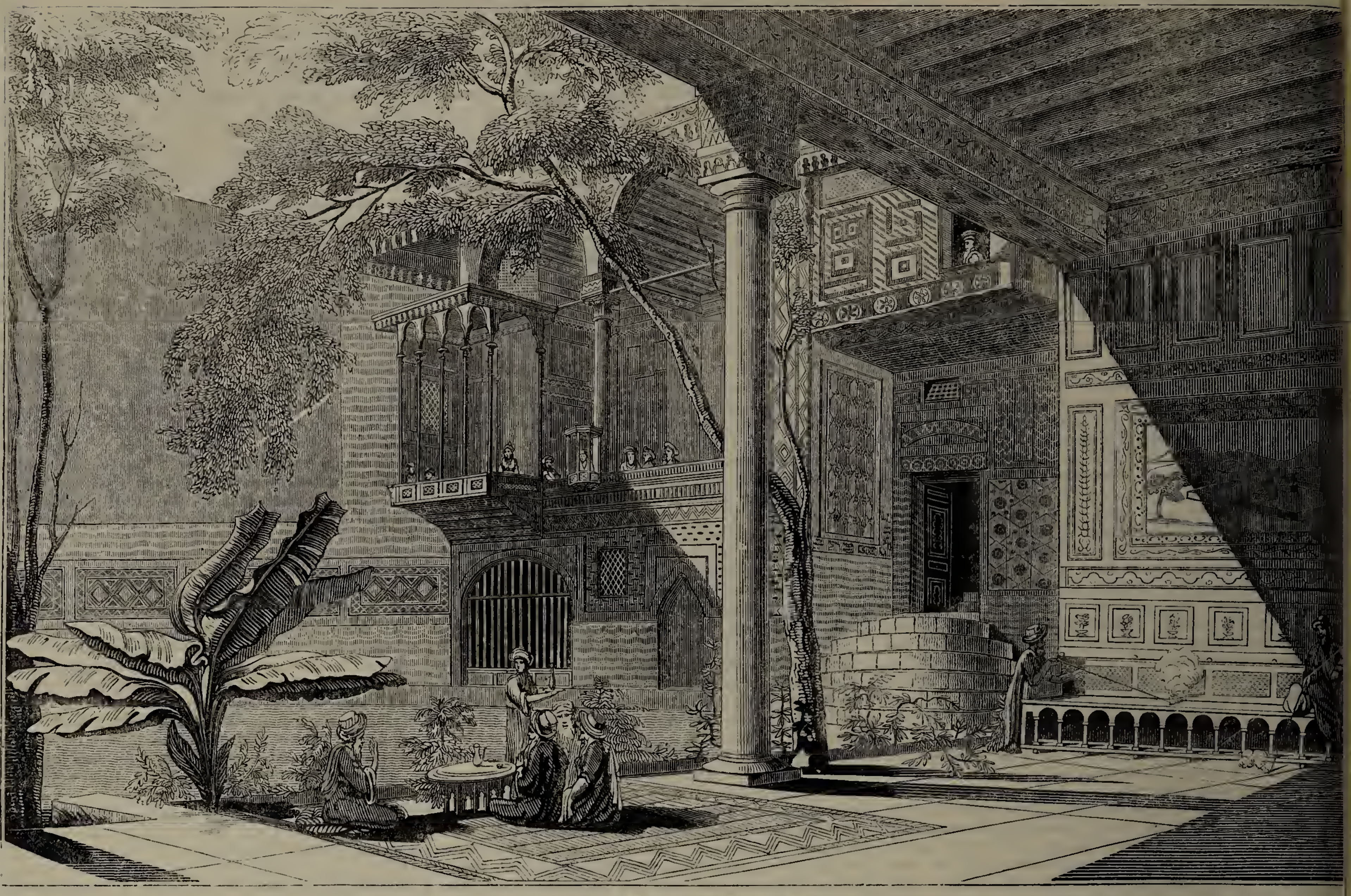
The windows of these houses are very differently placed from those to which we are accustomed. The windows of the ground-floor are a kind of small wooden grating, placed far above the heads of persons walking through the street: those of the upper apartments project a good deal, and are formed of wooden lattice-work, so close as to render it impossible for persons on the outside to see what is going on within; they are generally unpainted, but are sometimes enlivened by variety of colour. Some projecting windows are wholly constructed of boards, but a few have frames of glass; as a general rule, however, the windows are unprovided with this material.

Most of the houses are either two or three stories in height; and almost every house of moderate size has an open central court called a *kho'sh*, which is entered by a winding passage from the street, the windings being intended to prevent overlooking from the street. In the passage, within the door, is a long stone seat. In the open court is a well of water, which filters through the soil from the Nile; and on its shaded side are water-jars for containing fresh water. The principal apartments look into this court, the walls of which are plastered and whitewashed; and there are also many doors opening from it into the various apartments of the house. In Fig. 623 we see the general appearance which the court-yard of such a house presents. A more elegant and highly decorated specimen is shown in Fig. 624.

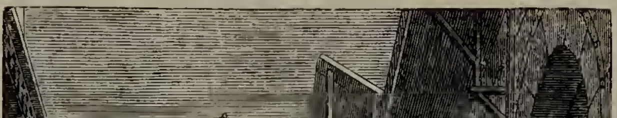
On the ground-floor there is generally an apartment appropriated to the reception of male visitors; this has a wide, wooden, grated window next the court. The general floor of this apartment is called the *leew'an*, while a smaller portion, having often a fountain in the centre, is called the *doorckd' 'ah*. The leew'an, or general floor, is usually paved with common stone, covered with a mat in summer, and a carpet over the mat in winter; the walls are plastered and whitewashed; and there are, generally, in the walls two or three shallow cupboards or recesses. Such an apartment (Fig. 625) is usually provided with cushioned seats.

In those streets of Cairo where shops occupy the lower floor of the building, the upper floors are let out in distinct apartments. These lodgings are separate from each other, as well as from the shop below. Each lodging comprises one or two sitting or sleeping rooms, and generally a kitchen; it seldom has a separate entrance from the street, one entrance and one staircase usually admitting to a range of several lodgings.

The humbler classes of dwellings in Cairo are of rather a mean description, being usually built of unbaked bricks cemented together with mud. They mostly comprise two or more apartments, but have seldom two stories in height. In Lower Egypt the peasants' houses have generally, in one of the rooms, an oven, at the end farthest from the entrance, and occupying the whole width of the room; it resembles a wide bench or seat, and is about breast-high; it is constructed of brick and mud, the roof arched within and flat on the top. The inhabitants, who seldom have any night-covering, sleep during the winter upon the top of the oven, having previously lighted a fire within it. The chambers have small apertures, high



624.—Open Court and House at Cairo.



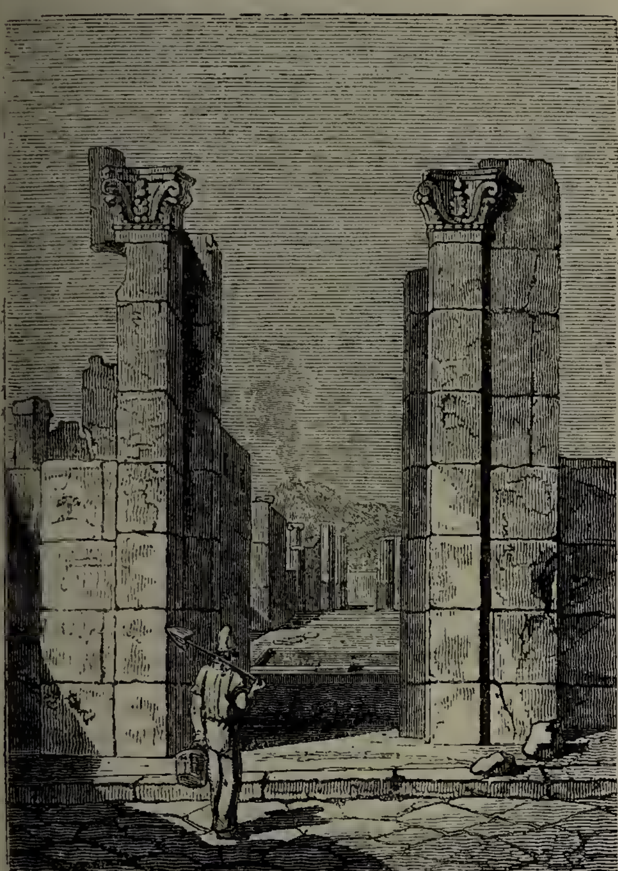
623.—Court of a Private House, Cairo.

622.—Entrance to a Private House, Cairo.

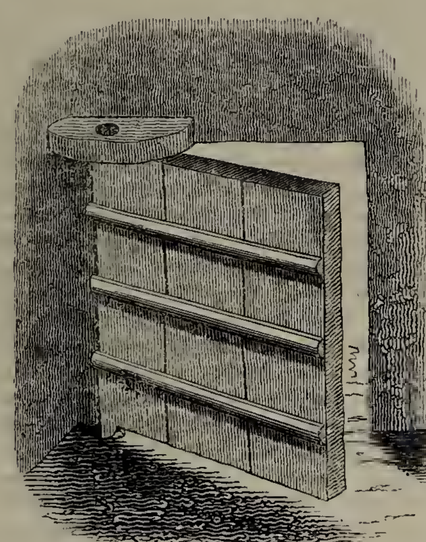
625.—Open Apartment in a House, Cairo.

629.—Supposed Interior of a House at Pompeii.

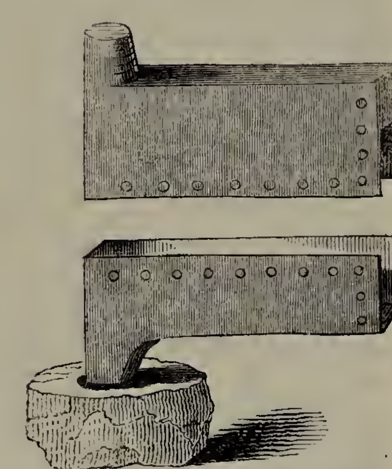
632.—Window at Pompeii.



628.—Remains of the Entrance to the House of Pansa, Pompeii.

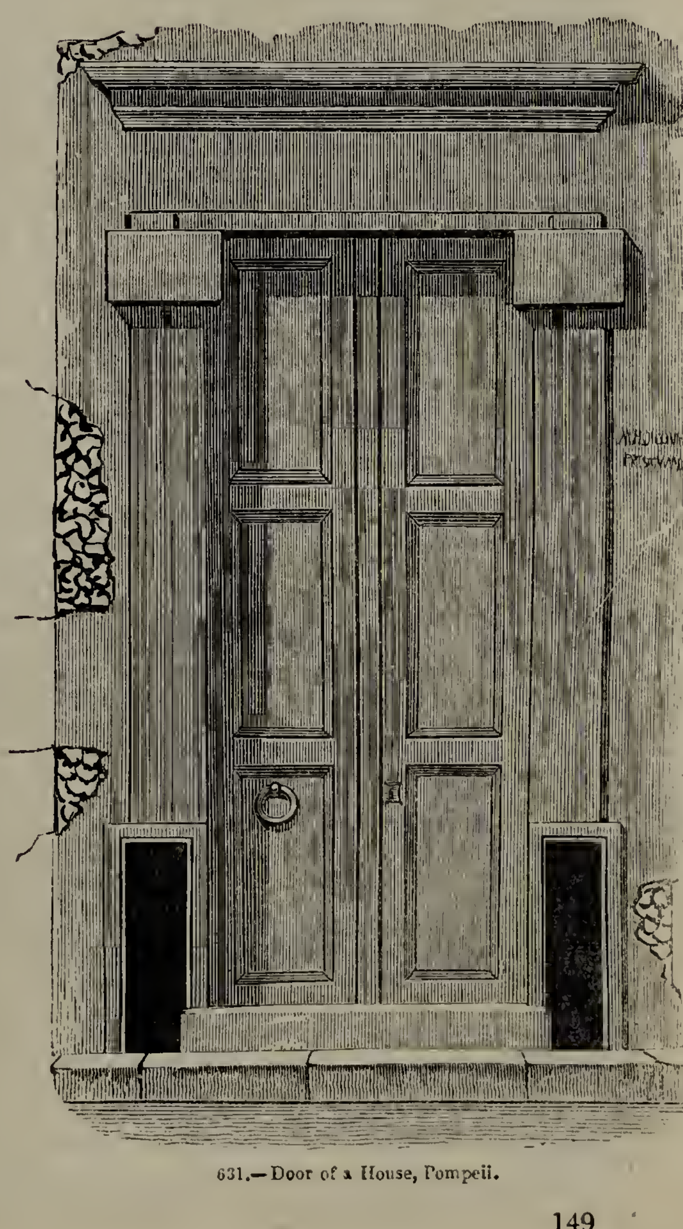


627.—Egyptian Door and Hinge.



626.—Egyptian Door-pins, or Hinges.

630.—Remains of the Entrance to the House of Sallust, Pompeii.



631.—Door of a House, Pompeii.

up in the walls for the admission of light and air, sometimes furnished with a grating of wood. The roofs are formed of palm-branches and palm-leaves, or of millet stalks, laid upon rafters of the trunk of the palm, and covered with a plaster of mud and chopped straw. Most of the villages of Egypt are situated upon eminences of rubbish, which rise a few feet above reach of the inundation, and are surrounded by palm-trees, or have a few of these trees in their vicinity: the rubbish which they occupy consists chiefly of the materials of former huts, and seems to increase in about the same degree as the level of the alluvial plains and the bed of the river.

Some of the Egyptian carpentry is of rather a rude kind; witness the doors, door-pins, and hinges depicted in Figs. 626, 627.

The ruined Houses of Pompeii.

It is a matter of much interest to compare the ruins of Pompeii with the productions of later date, as a means of determining wherein and how far the building-arts differed in periods very remote from each other. The calamity which brought ruin on so many when Pompeii was buried beneath the lava of Vesuvius, has been the means of handing down to later ages a more complete memorial of those times than would otherwise have been obtainable.

Much difficulty has been found in obtaining anything like an accurate idea of the houses of the ancient Egyptians and Greeks, and those of the Romans would have been similarly circumstanced but for Pompeii. With regard to the first of these three nations, the Egyptians, there is a model in the British Museum which is supposed to represent part of an ancient Egyptian house. So far as the model affords the means of judging, the house seems to have been about ten or twelve feet square, by fourteen or fifteen in height. The house has two stories; and in the lower part there is a court, the angles of the walls of which are raised a little higher in a sweep. The door opening into the court is low, and rather rudely constructed, the hinges being merely wooden pins let into a socket above and below. The stairs leading from the lower to the upper story are formed simply by a beam laid in an inclined position, with notches cut in it to form steps. The walls are plastered, and the door and doorcase are painted red. The roof, so much of it as is shown, seems to be flat.

The Greek houses were built so as to conform to the custom of that people, to separate the women's apartments wholly from those of the men. Those of modern Greece seem to be a kind of compound of the ancient form with that of the Oriental nations. "The modern Greek house is of a quadrangular form, with a court in the interior; the staircases are placed on the external part of the house, leading to a gallery round the first floor. The entrance is in the centre of the quadrangle; over the entrance is the sitting apartment of the women; a bow-window is placed in this apartment over the door: here, on a dais, the women sit and amuse themselves by watching the passers-by. In the lower story the cattle are often placed. The women's apartments are separated from the men's, as was the custom among the ancient Greeks. Many Greek houses are exceedingly mean and ill-furnished." ('Penny Cyclopædia.')

With respect to Pompeii, as a representative of Roman cities generally, the houses appear to have been of large dimensions, covering a great extent of ground, but not lofty; such at least was the character of the more important houses. The excavations have brought to light shops, private houses of a middling class, and large mansions; and it may be interesting to trace the particular features of each, so far as they illustrate the building-arts.

The larger kind of mansions appear to have been surrounded by shops, which were let out to tradesmen and dealers, and which were often a source of considerable revenue to the owners of the mansions. One of these shops has been so far excavated as to show its interior arrangement. The whole front of the shop is entirely open, except in being partly occupied by a broad stone counter, into which are built four large jars of baked earth, their tops even with the surface of the counter. Behind the shop are two small rooms; and traces of a staircase seem to indicate that there was an upper story. The front of the shop was closed at night by shutters, which were made to slide in grooves cut in the lintel and basement wall before the counter. There was an oven at the end of the counter farthest from the street, and three steps on the left side. From all these indications it is presumed that the shop was a kind of cook's shop, for the sale of meat or provisions; the oven being employed to dress the victuals sold, and the jars to contain oil, olives, and other accompaniments for the table. Another excavated shop seems to have afforded more accommodation: there is by the side of the shop a passage leading to a covered court, on one side of which is a chamber, on another a staircase leading to a small room over the kitchen.

A small private house which has been excavated exhibits, first, an entrance passage; then, a staircase leading to a small room which was probably a bedchamber, and also to a terrace extending over the length of the passage; on one side is a small room, and on the other a larger room, supposed to have been an eating-room. There was an open court covered by trellis-work, and a cistern to receive rain-water for domestic use. Such cisterns were very common at Pompeii, and were carefully made; the walls were lined with a strong cement, made of five parts of fine mud and two quicklime, mixed with flints; the bottom was paved with the same material, well rammed and consolidated: in order to make the water perfectly pure, there were often two or three of these cisterns on different levels, so arranged that the water might successively deposit the impurities with which it might be charged, by flowing from one cistern to another and remaining a short time in each. In another part of the same house was a *lararium*, or domestic chapel, very small in size, with a bench extending along two sides of it; in the centre was a small altar; near which was a painting representing a goddess (the deity of the house) reclining on a kind of couch.

Another house of a larger and more important character is the Casa Carolina, or Queen Caroline's House, so named because it was excavated in the presence of Queen Caroline. There is first a vestibule; then an atrium, or large hall, the roof of which is supported by square pillars painted with foliage, as if in imitation of climbing plants. On the left hand of the entrance is a kitchen having a window looking into the street. Around the atrium are several rooms, one of which appears to have been the lararium or chapel. From the atrium a passage leads to another division of the house, which contains all the apartments necessary for a small but separate establishment, and could have been made such by merely closing up a door in the passage. There are an entrance from the outer street, an open court, a kitchen, and three or four rooms, belonging exclusively to this division of the house.

Almost all the houses which have been excavated at Pompeii have had names given to them, as a means of distinguishing them one from another; these names often arise from some very trifling circumstance, but are sometimes derived from inscriptions found on the ruins of the houses themselves. Thus, one of the houses has the inscription PANSAM. ÆD. painted in red near the principal entrance; and hence it has obtained the name of the House of Pansa, who is supposed to have been one of the chief men of Pompeii. Another is called sometimes the House of Sallust, and at other times the house of Actæon, from a painting found in it. These two houses are of large size, and deserve the minute attention which has been given to them by Gell, Mazois, and other writers.

The House of Pansa forms a complete cluster in itself; that is, it is bounded by four streets on the four sides. Including a garden attached to the house, the whole length is three hundred feet, and the width one hundred. There is an entrance passage (Fig 628) paved with mosaic; and beyond this an atrium, the general arrangement and appearance of which, if restored according to what is believed to have been the customary style among the Pompeians of rank, would be such as is sketched in Fig. 629. In Roman houses generally, the *atrium* was a hall or room of audience. It had a roof or ceiling over part of its area, but was open over head in the middle; and as the rain could gain admittance through this opening, there was an *impluvium*, or cistern, in the middle of the mosaic or paved floor, for its reception. The atrium was the most important and usually the most splendid apartment of a Roman house; the owner received his morning visitors in it, for they were not admitted into the inner apartments. Originally the atrium was the common meeting-room for the whole family—the place of their domestic occupation; but in the better class of houses it afterwards came to be more a room of ceremony. There were many kinds of atria, according to the arrangement of the several parts. The oldest and simplest was merely an apartment, the roof of which was supported by four beams crossing each other at right angles, the included space forming the *compluvium*, or hole in the roof through which the rain fell. In another kind the main beams were supported by pillars placed at the four corners of the impluvium or cistern. In another kind, called the Corinthian atrium, the hole in the roof was larger, and the supporting pillars more numerous. A fourth kind had its roof inclined the contrary way, so that the rain flowed down to the outside of the house, instead of towards the opening in the centre. Lastly, there was a kind of atrium without any opening at all in the roof, or any impluvium in the floor.

But to return to the House of Pansa. From the atrium, an opening leads to the peristyle. Around both the peristyle and the atrium are numerous apartments, the precise nature of which can only now be conjectured; some are supposed to have been reception-rooms, some sleeping-rooms for guests, other sleeping-rooms for the host and his family; one a winter dining-room, another a summer dining-room, another a kitchen, another a servant's hall. There are slight indications of an upper story; but the staircase leading up to it has so utterly perished that its site cannot be determined.

This house of Pansa's, like many others in Pompeii, seems to have had numerous shops attached to it, which were let out to other persons, and probably produced him a good rental. On either side of the entrance from the street these shops were situated. Three or four of them appear to have been retail shops; another was a shop belonging to the house, intended for the sale of the spare agricultural produce of the owner's estates (a custom still pursued by the Italian nobles at their palaces); two others were baking establishments, and another was a baker's shop.

The House of Sallust appears, from the vestiges of it yet remaining, to have been very similar in character to that of Pansa. Its entrance (Fig. 630) was lofty and imposing, and its interior arrangements were extensive; but the details concerning Pansa's house will preclude the necessity of any further description here.

The materials of which the houses at Pompeii were built are pretty much the same as those now used among ourselves. The stone employed in the houses was generally of an inferior kind; brick being used for the greater number of the private dwellings. The stone was so easily acted on by the air, that many of the walls and buildings have crumbled away since they were excavated from the lava. The mortar employed also seems to have been less solid and durable than that used in the great public buildings at Rome; a circumstance attributed not so much to the want of good materials as to an imperfect mode of working them up.

Among all the relics of former times discovered at Pompeii, not one specimen of a wooden door is said to have been met with. The door represented in Fig. 631 is of marble: it is here given in the form which, from collateral evidence, it is supposed to have presented when in a perfect state—a species of licence which architects and artists allow themselves, and which they call "restorations." Almost all the doorways are nearly alike in size and form; the chief difference being in the capitals and entablatures. They were generally what we should now-a-days term "folding-doors;" turned on pivots instead of hinges, and had large bolts for fastening into the threshold. The wooden doors which may once have existed were all burnt, or at least carbonized by the heat of the lava and ashes when the irruption took place. From some fragments of carbonized timbers met with, fir-wood seems to have been much employed.

According to the evidence afforded by the existing remains, the streets of Pompeii, except where public buildings were grouped together, would not have presented anything like a striking or magnificent appearance. The houses were low, and externally gloomy; the lower part being usually a blank wall plastered over, and often painted with different colours; the upper pierced with small windows to light the apartments on the first floor. Fig. 632 represents such a window as this. There are six of these windows in a row, all raised six feet six inches above the foot-pavement; the pavement itself being raised nineteen inches above the centre of the street. The windows are small, being scarcely three feet high by two wide; at the side is a wood frame, intended probably to contain either a sliding sash or a sliding shutter. The lower part of the wall is occupied by a range of red panels four feet and a half high.

Respecting the general character of the houses, and of the streets in which they were situated, it has been remarked that "expense and ornament were reserved for the interior, on which they were profusely lavished; not a house yet found in Pompeii has any pretensions to architectural merit on the score of its elevation; not a house yet found is ornamented with a portico. The Villa of Diomedes possesses a porch, formed by one detached column on each side of the doorway; and this is the only approximation to a portico in the place. . . .

The general narrowness of the streets, however repugnant to our notions of beauty, comfort and salubrity, is by no means peculiarly the reproach of Pompeii, but common to the Italian cities of the age in which it perished. Nor, indeed, was that narrowness generally considered a blemish; for when Rome was burnt during the reign of Nero, and the Emperor caused it to be rebuilt with more ample streets, persons were not wanting to say that 'the ancient form of the city was more healthy, because the narrowness of the streets and height of the houses afforded little access to the sun's rays; henceforward the extent of opening, unprotected by shade, would burn with more distressing heat.' Similar croakers probably were not wanting to complain of the changes in building introduced after the Fire of London; though our northern climate does not offer such plausible objections to the free admission of light and air as were to be derived from the torrid sun of Italy." (*Pompeii*, vol. ii.)

Houses on the Continent.

It will not be necessary, in furtherance of our object, to pursue the present details to a much greater length. When we leave ancient times for modern, and Oriental countries for those of Europe, and rude nations for others more civilized, we find that the distinction between the houses of different countries can-

not well be maintained without entering upon the subject of architecture, which, being a Fine Art rather than an Industrial Art, does not fall within the scope of this volume. It may, however, be well to glance at a few of the most striking features abroad, and then to notice some matters nearer home.

The larger mansions of Paris generally obtain the name of *Hotels;* and concerning these Mr. Cooper, in his 'Residence in France,' makes the following remarks:—"The private hotels are even more numerous than the public gardens, land not always having been obtainable. Of course these buildings vary in size and magnificence, according to the rank and fortune of those who caused them to be constructed; but the very smallest are usually of greater dimensions than our (American) largest town-houses; though we have a finish in many of the minor articles, such as the hinges, locks, and the wood-work in general, and latterly in marbles, that is somewhat uncommon even in the best houses of France; when the question, however, is of magnificence, we can lay no claim to it, for want of arrangement, magnitude, and space. The hotels bear the names of their owners. The higher classes of the nobility were accustomed to build a smaller hotel near the principal structure, which was inhabited by the inferior branches of the family, and sometimes by favoured dependents,—this is called the *petit hôtel.* Our first apartments were in one of these petit hôtels, which had once belonged to the family of Montmorenci."

Of the houses of Seville, so far as they present a general character, Mr. Standish has given the following description. There is much of the picturesque in the grouping and arrangement of the houses. An entrance leads into a court, round which are rows of columns, with arches between the columns to support galleries or rooms above. It is usual to inhabit the ground-floor in summer-time and the upper story in winter. In the former season a canvas awning is placed over the whole court during the heat of the day, and removed at night, when the family collect together to receive friends under the galleries or in the courts.

Many of the Spanish villages, in the provinces of Castile and Leon, have a strong general resemblance one to another in their style and arrangement. The houses are very small, and seldom higher than one story. The interior is usually whitewashed, the floor paved with bricks placed sideways, and the walls ornamented with some gaudily coloured French engravings of saints and martyrs. There is generally only one window, and this is small and often unglazed; having a shutter, or a piece of oiled paper, sometimes attached to it, to keep out cold. The walls outside retain the natural colour of the clayey soil of which they are formed, excepting a space of a few feet on each side of the door, which is ornamented (or disfigured) by rude representations of flowers, or men painted in red on a whitewashed ground—a remnant of an ancient Moorish custom. The walls are formed of large bricks or masses of unburned clay, of nearly a yard in length by twelve or eighteen inches in breadth. They are usually supported within a few feet from the ground by two or three layers of large square stones. At the door, which is usually divided into two parts, like those of some of the old-fashioned shops in English towns, and thickly studded with large round-headed nails, are two or three large blocks of stone, on which the women sit while spinning during the greater part of the fine days.

Every city in Italy has its own peculiar kind of dwellings. In Florence the houses of the better classes are almost palatial in their character. Bell observes that in the best streets "every house is a palace; and a palace in Florence is a magnificent pile of a square bulky form, with a square front extending from two to three hundred feet, built of large dark grey stones, each measuring three or four feet." The general structure of these houses is as follows. There is a course of rubble-work rising to a height of twenty or thirty feet from the ground. A stone seat runs the whole length of the front, which used, in former times, to be occupied by the dependents of the family, who frequently slept there, sheltered from the sun by an overhanging cornice. Large iron rings are sometimes seen fixed into the wall; these were formerly used to contain the banners of the owner, to hold flaming torches, and to fasten horses to. The lower range of windows are grated and barred with massive iron frames, which present much of the melancholy effect produced by prison-windows. On the second story is a plain and simple architrave; the windows are high and arched, placed at a considerable distance apart, and from ten to fifteen in number according to the width of the building. The third story resembles the second in its plainness and in the number of its windows. The roof is flat, with deep cornice and bold projecting soffits, which give a grand and magnificent effect to the whole edifice. The chimneys are grouped into stacks, the tops of which, increasing in bulk as they rise in height, resemble a crown. The slates with which the chimneys are built are ranged so as to act as ventilators. Two or three steps lead up to the porch of the mansion, the doors of which are studded with iron, for the sake both of strength and ornament, and the entrance is an arched massive gate.

The general character of houses in Italy, as in those of France, is to have a floor containing a series of rooms, each series being occupied by one family. The staircase, as in the "chambers" of our English Inns of Court, is common to all the floors. The rooms communicate with each other, and often also with a passage or balcony on one side. Chimneys are rare; stoves being more frequently used to heat the rooms. The windows are not hung with pulleys and weights, as in England, but are formed of two folding glass doors on hinges. The houses have generally projecting roofs with broad overhanging eaves; whereas in England the gutter is usually concealed within a parapet-wall. Bricks are much less used for houses in France and Italy than in England, rough stone stuccoed over being used instead.

At Vienna many of the dwellings are quite extraordinary for their size; indeed some of them contain so many distinct habitations that they resemble rather a village or hamlet than a single house. It is mentioned by one of our tourists that there is one house in Vienna containing ten large courts inhabited by twelve hundred persons, and yielding an annual rent of more than six thousand pounds sterling. Houses of smaller dimensions have generally a court into which the inner windows of the house look, but this court is mostly very small. Most of the houses contain a great number of families; but there is one master, called the *haus-meister*, or house-master, who is put in by the proprietor to superintend the conduct of the house, and who locks up the outer door at a certain hour in the evening—any subsequent opening being only obtainable by a fee to the haus-meister.

In Switzerland the houses are smaller than those of Italy, France, or Spain; and each generally occupied by one family. Those constructed in the vicinity of the pine-forests are really log-houses, though finished in a very picturesque manner. The walls are formed of whole trees neatly squared and notched into each other at the ends where the walls cross. The roof is of wood. Short pieces of pine split into thin layers are used as tiles, and held together by small spars laid across them, which are again weighed down by stones. Many of the cottages have wooden chimneys, the whole of the flue being formed and lined with wood—the smoke and turpentine combining to produce a varnish which preserves it from taking fire. The beams supporting the roof, as also the principal front, are often elaborately ornamented; and the houses have altogether a picturesque appearance.

In Northern Germany and Russia the houses are of very varied character, scarcely admitting of classification. In many parts of Germany the houses consist of a framework of wood; with the interstices filled with unbaked bricks, and plastered with clay. In North Prussia a similar arrangement is followed; and the upper story is often made to project over the lower, supported by columns. In Russia the city houses are something like those of France and Italy, with the exception of having the roofs covered with gaudily painted sheet-iron. The village houses of the same country are mostly log-houses, having a staircase within the house, and not outside as in Swiss cottages: the roof has a high pitch or slope, and is covered with sawed boards projecting six feet from the walls; whereas the Swiss roofs are flat, and generally covered with wooden shingles. The chimney is of brick. The villages on the by-roads are of much ruder construction; the rafters project above the ridge, and form by their closeness the entire covering; the projections above the ridge are sometimes cut off, and the ridge-piece is introduced, on which is rudely carved the representation of the head of some animal. These villages generally consist of one street, presenting on each side a range of bold projecting gables. The houses are of two stories: some of the better village-houses have a third story in the roof, and a colonnade with a balcony on the ground-floor, and occasionally a second balcony from the attic, the balconies being always in the gable front. In the villages there is a side-entrance, with a penthouse roof over it, leading into a court where the sheds for the cattle are placed.

General Character of English Houses.

It would be somewhat difficult to say what is the general character or arrangement of English dwellings, were it not that the plain uniform brick houses of London form a sort of standard. In country places the diversity is much greater, and there is therefore greater uncertainty in characterizing them.

"Three centuries ago," says a recent writer, "the English house was constructed in a very different manner from the houses of the present century. The chief materials were wood and plaster, and a common but peculiar feature was the projecting upper floors. The internal arrangement was adapted to the wants of that day, and the external architecture had often a picturesque appearance. The Butter-market at Ipswich contains a remarkable specimen of a house of this period." There are beyond all doubt numerous towns where other specimens of this quaint but often picturesque style of building are observable. Witness the old houses at Coventry and at Warwick (Figs. 633, 634), with their fronts broken up into all kinds of devices, contrasting strongly with the excessive and inelegant plainness of too many of our modern brick houses.

The country cottages of the olden time were marked by an utter absence of that attention to neatness and order which is so much observable in the present day: all was hearty and hospitable and cheerful, but it was rough and uncouth; the change produced by time has been beneficial in some respects, but not in all. Very little furniture or adornment was looked for; the doors, the windows, the shutters, the stairs, were sufficient for the main object in view; but the thousand little conveniences and knick-knacks, which the modern extension of the arts of working in metal has mainly placed within the reach of every one, were then scarcely to be had. Locks, bolts, handles, hinges, fire-grates, fire-irons; and vessels, implements, and utensils without number—all were so difficult to procure in former times as compared with the present, and were mostly of so rude a kind when procured, that the modern cottager, unless very poor indeed, has a greater superiority over his ancestors than he is in the habit of thinking. Notwithstanding the glow (often more pretty than real) which dramatists and poets throw around the hearth of the "bold yeoman of yore," the cottages of the peasants in the country, and the dwellings of the poorer inhabitants of the towns, appear to have been but sorry affairs in most cases. If, in the alleys and courts of our crowded cities, there are houses of misery such as to make the heart sick to read of, the misery is derived from other causes than the house itself; for, poor as it may be, the humble dwelling is built of brick, and has glazed windows, and a tiled roof, and boarded floors (except the cellar or kitchen). Three centuries ago, however, the poorer houses were built principally of wood, often assisted by mud or clay, which, cracking by the heat of summer or the frost of winter, was repaired by the application of the same material. Harrison, who wrote a 'Description of England' about the year 1580, says:—"In the fenny countries and northern parts, unto this day, for lack of wood, they are forced to continue the ancient manner of building (houses set up with a few posts and many raddles), so in the open and champain countries they are enforced, for want of stuff, to use no studs at all, but only front posts and such principals, with here and there a girding whereunto they fasten their splints or raddles, and then cast it all over with thick clay, to keep out the wind. Certes this rude kind of building made the Spaniards in Queen Mary's day to wonder and say, 'These English have their houses made of sticks and dirt, but they fare commonly as well as the king.'"

The Great Fire of London in 1666, among its other effects, showed strongly the advantage of employing brick and stone as much as possible in building. A great change thereafter took place in house-building in the metropolis, which extended by degrees to the houses rebuilt from time to time in other parts of the country. In this gradual change, the projecting floors with large bow-windows, the wooden galleries around the quadrangular courts, the boldly projecting dripping-eaves, and the high-pitched roofs with their large windows—have all alike nearly disappeared. In the latter part of the eighteenth century an act of parliament was passed for the improvement of house-building in the metropolis, as far as regarded strength, protection from fire, and the gradual removal of the old-fashioned projections.

A modern London brick house is too familiar in respect to its general construction and arrangement to need description here; but there are certain changes, which came into operation on the 1st of January in the present year 1845, very little known to readers generally. By the clauses of this Building Act, before the walls of any building shall have been raised to the height of ten feet, a good drainage must have been made for the house. Every new street must be at least forty feet wide; and if the houses are more than forty feet high, the street must equal in width the height of the houses. The same is applicable to alleys and courts, with the substitution of twenty feet for forty as a limit. No underground cellar is to be let off as a living-room. Every new house and every house rebuilt must have an enclosed back-yard, and windows looking into it from the house, unless all the rooms of the house can be lighted by windows from the street. Every kitchen or underground living-room must have in front of it an open area not less than three feet wide, an open fire-place, and a glazed window capable of opening. Any garret or room in the roof must be not less than seven feet high, and the slope of the side must not commence at a height of less than three feet and a half from the ground. All the other rooms in a house must be at least seven feet in height. All these provisions, and numerous others, are intended to improve the drainage, the lighting, the ventilation, and the general salubrity of dwellings; no doubt can exist as to the excellence of the object in view; but it remains to be seen whether such technical minuteness in the law can be carried out in practice.

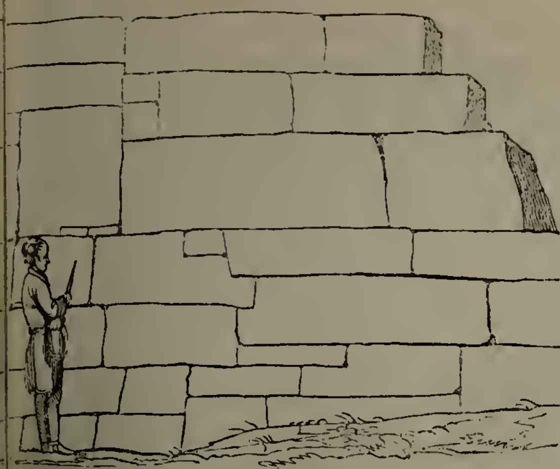
636.—Old Timber Mansions; Hulme Hall, Lancashire.

637.—Interior of a Chester "Row."

635.—Old Houses in Chester.

634.—Old House at Warwick.

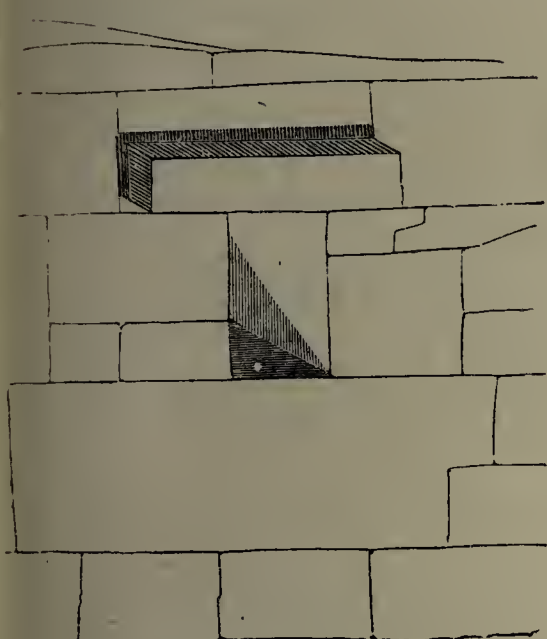
663.—Old Timber Houses at Coventry.



638.—Ancient Masonry, Italy.

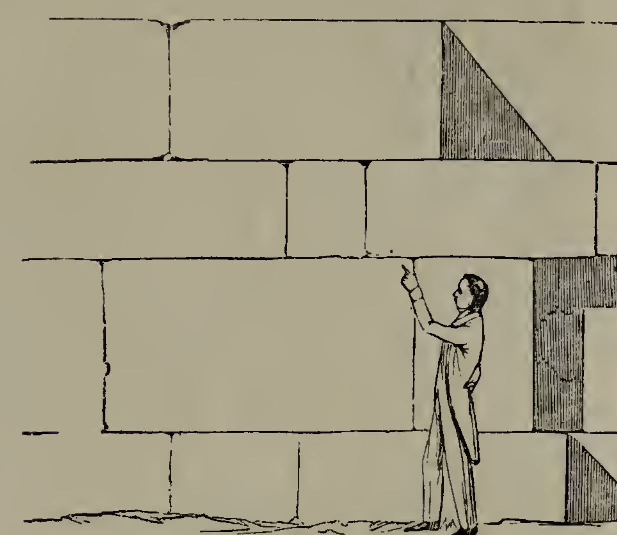
639.—Ancient Masonry, Italy.

645.—Ancient Masonry, Greece.

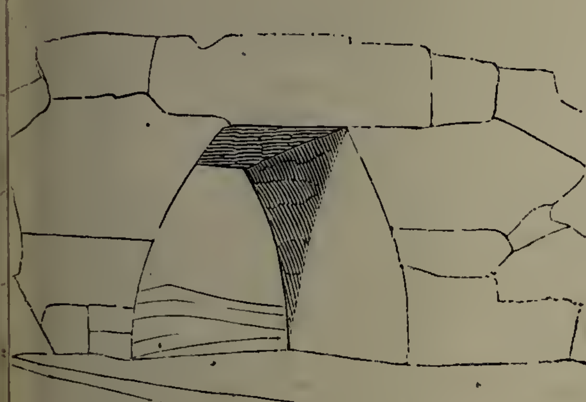


641.—Ancient Masonry, Italy.

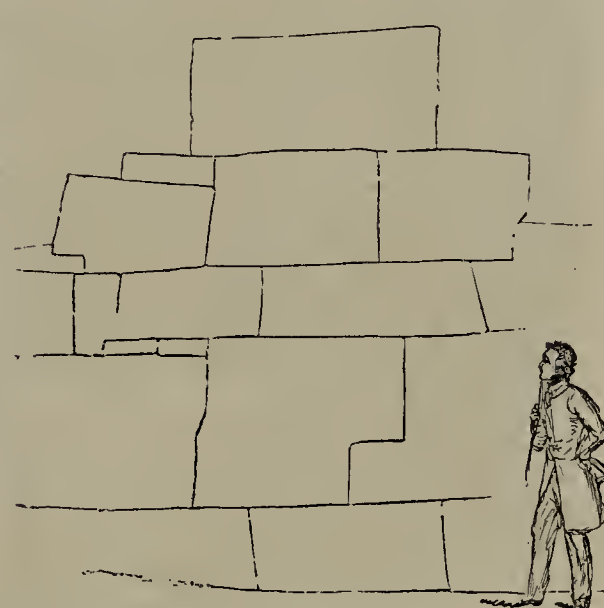
644.—Ancient Masonry, Greece.



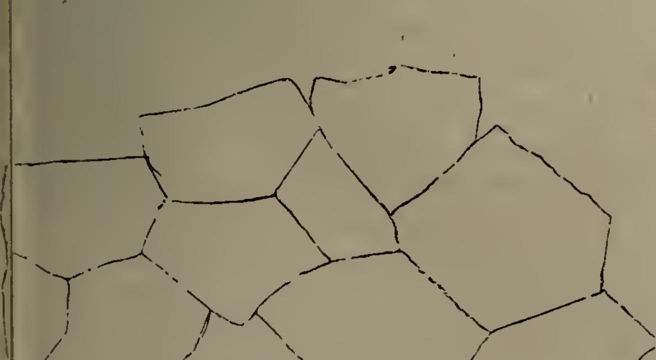
640.—Ancient Masonry, Italy.



643.—Ancient Masonry, Italy.

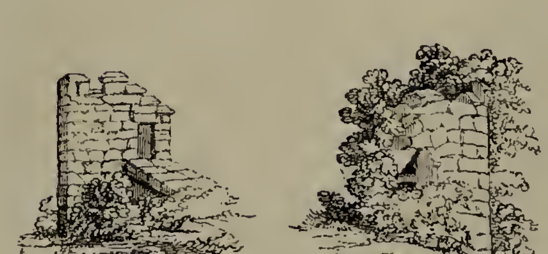


642.—Ancient Masonry, Italy.



646.—Ancient Masonry, Greece.

647.—Ancient Masonry, Italy.



648.—Ancient Masonry, Greece.

It may be remarked, that where attempts are made to display taste or architectural beauty in the form of a middle-class English house, very slender success is attained; for a mere builder's architecture has seldom anything to recommend it. On this matter a writer in the 'Penny Magazine' (No 478) has observed:—

"There is a woful perversion of what is called taste exhibited in the little villas or cottages which surround the metropolis and fill its suburbs; and although in comfort, cleanliness, and neatness of appearance a vast improvement in such buildings has taken place of late years, there is yet much to be accomplished ere they attain all that architectural elegance which they are capable of receiving. Although occasionally we meet with something original in the design of these buildings, the architects of most of them appear to have followed but one model, and that one only distinguished for the extreme deficiency of exterior ornament: this quaker-like simplicity of appearance, however advantageous in some respects, is, we think, misplaced in buildings destined to be places of retirement for those who, wearied by business, seek the amusements and leisure of a rural habitation. The vicinities of Bayswater, Maida Hill, Hampstead, Islington, Hackney, Camberwell, and other suburban districts, are like so many multiplying glasses, in which, wherever we direct our attention, we discover objects similar in form, size, colour, and unornamented plainness."

If the plain brick house is the type of London dwellings, the old picturesque Elizabethan mansion is the best representative of those which distinguish our country districts. Wollaton House, near Nottingham, is one of the best specimens of this class; and a few descriptive details of it will not be misplaced here. The house is approached through a winding avenue of lime-trees, nearly a mile in length, and presents a very fine frontage and general appearance. The building is square, and has four large towers adorned with pinnacles; in the centre the body of the house rises to a greater height, with projecting coped turrets at the corners. Square projecting Ionic pilasters adorn the front and sides. Mr. Nash, in his 'Mansions of England in the Olden Time,' says, that "in grandeur and unity of design, though not in extent, this noble edifice, in respect to its external beauty, may be considered the most striking of the numerous magnificent mansions of the Elizabethan era. The garden-front of the mansion is the most richly decorated; the entrance-front being somewhat similar. The building forms a square, in the centre of which is the hall, occupying the whole ground-space of the central tower—a very remarkable feature of the edifice, and to which all the rest of the building is subordinate. In this, as in almost all other of the Elizabethan mansions, the masonry and workmanship are so excellent, that they have more freshness of execution in their details, as well as solidity in their construction, than many buildings of recent date." The entrance hall is decked round with arms and armour, as in the olden time. The great hall, the pride of the mansion, is a noble and beautiful apartment. It is nearly square, and twice as high as its length or breadth; it has a boldly constructed roof, a richly decorated stone screen, a gallery with an organ, ceiling and walls painted by La Guire, and such emblems of war and hunting as used to decorate the halls of the old mansions. The saloon, the principal and secondary staircases, the dining, drawing, and billiard rooms, the turret-rooms, from which entrance is gained to terraces on the roof of the house—all are consistent with the picturesque and highly decorated style of the building in other respects.

Hulme Hall, in Lancashire (Fig. 636), recently pulled down, was a good example of the half-timber manor-houses built in the sixteenth century. In these houses the framework of the walls consists of horizontal beams resting on upright timbers, which are sometimes very close together; and where these uprights are more distant, diagonal timbers extend from the top of one to the bottom of the other, and so on alternately. Sometimes the diagonals are curved or angular, or are otherwise varied in form. The floors generally overhang each other, and the roof is often continued over the top of the framework, so as to form a protection from the weather at the top as well as the bottom. The roof, which was usually high and sharp, was mostly relieved by dormer windows. The gables, diversified and rich in their ornaments, are sharp in the inclination of their sides, corresponding with the steepness of the roof. Galleries and balconies of open carved work were frequently made in such houses. The windows of the principal apartments were large and square, divided into compartments by richly traced mullions and transoms. The doors were deeply recessed; and there were often porches to the entrances, with small gable-tops. To the larger houses there were sometimes turrets; and the ornamental chimneys were usually made as diverse as possible. In the general construction of these picturesque old houses, the spaces between the framework timbers were filled in with plaster; and the materials have, in some instances, been allowed to decay, while in others the house has been pulled down to make way for the tasteless modern brick houses; but there still remain, scattered in various parts of the country, a good many examples of this thoroughly "old English" style of mansion.

This slight glance at English houses may be terminated by a few words concerning a curious street-frontage arrangement observable in some of the houses in Chester. The houses are so connected one with another as to form what are called "rows," the nature of which is shown in Figs, 635, 637. These rows are a sort of gallery, arcade, or piazza, up one pair of stairs. The galleries at present occupy the greatest part of both sides of Eastgate Street and the upper part of both sides of Watergate and Bridge Streets. They run along what would, in other towns, be the first floor of the houses, reaching from one end of the street to the other, open in front, and balustraded. Beneath the "rows" are shops or warehouses on the level of the street; and at occasional intervals there are flights of steps leading into the rows. The upper stories over the rows project to the street, and are on a level with the shops and warehouses below. In a description of Chester, published in 1656, the "rows" are thus alluded to:—"The buildings of this city are very ancient, and the houses be builded in such sort that a man may go dry from one place of the city to another, and never come in the street, but go as it were in galleries, which they call the rows, which have shops on both sides and underneath, with divers fair stairs to go up or down into the street; which manner of building I have not heard of in any other place in Christendom." Pennant supposed these "rows" to have been the same with the ancient vestibules, and to have been a form of building preserved from the time that the city was possessed by the Romans; and Ormerod agrees in the conjecture. Their origin is accounted for by supposing that they were intended to enable the citizens to seek refuge from any sudden inroad of cavalry in the streets.

THE MATERIALS AND PROCESSES OF BUILDING.

Our attention may next be directed to the modes in which the strength and ingenuity of man have enabled him to construct dwellings out of the rude materials by which he has been surrounded. These, so far as mechanical principles are concerned, have been pretty much the same in all ages, and have been guided by the kind of materials presented to the hand of the workman. These materials are mainly stone, wood, brick, and slate, each of which has its own peculiar qualities, and requires its own peculiar mode of working.

Stone-Quarries and Masonry.

The kinds of stone employed in masonry are numerous. Granite, one of the hardest of all, is generally blasted with gunpowder as a means of moving it from its bed; and the detached masses are roughly hewn into shape on the spot with small pickaxes. Aberdeen and Peterhead granite is generally separated from the rocks by cutting a long deep furrow or fissure, placing strong iron wedges at intervals in this fissure, and striking the wedges with heavy hammers till the mass splits. In some cases a curious mode is adopted of separating masses of stone; a fissure is made in the surface, and in this fissure wooden wedges are placed; water is poured on the wedges, the wood of which they are formed swells by the absorption, and the stone is rent by this swelling or pressure.

For general purpose, some of the varieties of *limestone* are much more employed for building than granite or the harder rocks, as being more easily workable. Bath-stone, for instance, of which nearly all the buildings in Bath are constructed, is so soft as to be easily cut with a saw, like a piece of timber, and it is capable of being carved into ornamental forms with great facility; but it is very seriously acted on by alternation of weather, insomuch that it crumbles and decays in the course of (comparatively) a few years. The restorations of Henry VII.'s chapel at Westminster Abbey were unfortunately made with this stone, and they are already in a state of decay.

The relative values of different kinds of building-stones had scarcely been systematically inquired into until a few years ago, when Mr. Barry, architect of the new Houses of Parliament, suggested the appointment of a Commission, whose duty it would be to examine into the durability and other qualities of stone for building. The Commissioners visited more than a hundred quarries, and submitted specimens of stone to Professors Daniell and Wheatstone, for mechanical and chemical examination. They inspected a hundred and seventy-five edifices, including abbeys, cathedrals, churches, towers, castles, and other buildings; with a view of determining how far any particular degree of preservation or of decay depended on the use of any particular kind of stone. They found that limestone employed at Oxford had greatly decayed; as also magnesian limestone at York, and sandstone in Derby and Newcastle. In a report published by them, they gave the most minute account of all available particulars concerning each quarry—such as the name and locality, the names of the freeholder or agent, and the quarryman, the mineral designation of the stone, its colour and specific gravity, the depth of workable stone, a description of the beds and the size of the obtainable blocks, the price at the quarry, the cost of conveyance to London, the cost of working it, and the evidence of its durability or otherwise in buildings already constructed. The two professors in London tested numerous varieties of stone, in every way deemed likely to bear upon the object in view; and the result of the whole inquiry was a recommendation, on the part of the Commissioners, that the stone employed in building the new Houses of Parliament should be the magnesian limestone, or dolamite, obtained from a quarry at Bolsover Moor, in Derbyshire.

Whatever may be said of the moderns, the ancients certainly appear to have known how to select their building-stone with judgment, in many cases at least; for there are specimens still existing which must have been constructed at least three thousand years ago. It is only fair, however, to bear in mind, that as we do not know what proportion the decayed and the preserved specimens of masonry bear to each other, we cannot say how far credit is due to the judgment of the ancient builders in this respect. The pyramids of Egypt are a mighty example both of vastness and of durability, and must ever be regarded among the most wonderful specimens of masonry. The kind of stone employed by the ancients was not however the only point of interest in respect to the construction of their stone walls and buildings; the mode of shaping and connecting the stones was also in many instances remarkable. The still remaining walls of Pompeii, and of other towns in Italy and in Greece, illustrate some of the rudest modes in which stones are put together. Two very early styles of masonry, called the Cyclopean and the Etruscan, are met with in Greece and in Italy; and to the latter of these a large portion of the walls of Pompeii belonged. With respect to the terms Cyclops and Cyclopean, they relate to mythological matters, which have become strangely mixed up with history in the narrations of classical writers. Many of the walls of ancient fortified towns are said to have been built by a mighty people called the Cyclops; who these Cyclops are meant to represent, or by whom the walls were really built, are questions not easily answered at the present day; but it is known that many walls, such as those at Tiryns and Mycenæ, which must have been built at least three thousand years ago, still remain solid in construction, massively grand in their parts, and apparently scarcely injured by the lapse of so many ages.

The construction of the Cyclopean walls has been aptly compared to that of the dry stone walls which serve for fences in many parts of the north of England. Such fences are made where stone is plentiful, and where irregular masses, heaped together without much order, form a very efficient fence, and at the same time help to clear the stony ground of fragments which encumber it. So likewise is the Cyclopean masonry; the wall is built of huge polygonal masses of rock piled up on each other, without any artificial adaptation of their sides, but having the interstices at the angles filled up with small stones. Such walls were used at Tiryns, Mycenæ, and other places in Greece as a fortification to enclose the Acropolis, or elevated spot containing a palace, a fortress, and a temple. The space thus enclosed at Tiryns is two hundred and twenty yards in length, by sixty in breadth. The walls consist chiefly of rude unwrought masonry; but there are some galleries formed of stones, which seem to have been hewn by the chisel to a definite contour.

The enclosure at Mycenæ is larger than that at Tiryns. The greater part of the walls consist of polygonal or variously shaped blocks, well fitted into each other in some instances, but in others exceedingly rude of construction. It is observable that there is a great difference between two kinds of Cyclopean masonry; in the one, the large blocks seem to have been selected without any regard to shape, and to have been placed one upon another without much order or system, the interstices being afterwards filled in with smaller stones; while in the other the blocks are chosen with such reference to size and shape, that the convexities and protuberances of the one may fit into the concavities and hollows of the other. A later style, but still Cyclopean in being without the use of mortar, consists in having the stones ranged in pretty nearly horizontal courses, though the transverse joints are irregular instead of vertical. This more regular style, however, is found rather in Etruria (an ancient name for a part of Italy) than in Greece. In the remains of an ancient Etruscan city, near the river Ombrone, the walls are a mile and two-thirds in circumference, built of enormous masses of travertine or coarse limestone, having the exterior surface worked to an even plane; many of the blocks are fourteen or fifteen feet long, and of enormous thickness. In the ruins of another of the Etruscan towns the walls are built of solid blocks of pure white marble.

At Pompeii, wherever the ancient walls still exist, they consist of courses of stone laid rudely horizontal,

but with the joints inclined to the perpendicular. Some of the stones are dovetailed into each other. On the north and north-east, the ramparts consisted of an earthen terrace fourteen feet wide, walled and counter-walled, which was ascended from the city by flights of steps broad enough for several men abreast. The greater part of the walls are built of lava, and the rest of coarse limestone; all the stones being well joined, but without mortar.

The various kinds of masonry above alluded to under the names of Cyclopean, Etruscan, and Pompeian, are illustrated by many representations from ancient walls still existing, in the next eleven cuts (Figs. 638 to 648).

The position of the layers of building-stone in the various quarries, and the commercial features presented by the working and disposing of the stone, differ in different districts; but it may be sufficient, so far as our own country is concerned, to describe the Portland Quarries, as a type of all generally.

The Isle of Portland, from which such a vast quantity of building-stone is obtained, is situated near the coast of Dorsetshire, with which it is connected by a narrow pebbly belt called the Chesil Bank; the two being so oddly shaped as to cause Portland to be compared to a "breast of mutton suspended to the mainland by a string." The isle itself, which is about four miles long by one and a half broad, consists of a rock of freestone, the highest point of which is nearly five hundred feet above the level of the sea. Near the western cliffs are the quarries from whence the stone is obtained. These quarries belong to the crown as lord of the manor, but are let out to tenants under various forms of tenure; they are about a hundred in number, of which the crown holds and works about one-fourth, the rest being farmed out at a rent amounting to something about two shillings for every ton of stone raised and shipped. The management of each quarry is intrusted to an agent, who has under him a foreman and a company of six quarrymen and two boys. The agent and the foreman are paid a fixed salary, but the earnings of the quarrymen depend on the quantity of stone raised—a system similar to that adopted in mining districts.

The position which the Portland freestone occupies with respect to other geological strata may be seen by an inspection of Fig. 649. There is first seven feet in depth of the surface-soil; then sixteen feet of a kind of grit-stone, called by the quarrymen "turf-layer;" then nine feet of roach-stone; and then the good Portland stone, which forms a compact horizontal bed about eight feet in thickness. Beneath this are layers of clay, black marl, clay mixed with flints, and other mineral beds. The work which the quarrymen have to perform, therefore, is to remove the seven feet of surface-soil, the sixteen of turf-layer, and the nine feet of roach-stone, before they can get to the Portland stone at all. All this is a work of great labour. First, the surface-soil and rubbish are dug up and wheeled away in barrows to fallow-fields in the neighbourhood. The "turf-layer" is harder, and requires the aid of wedges and other contrivances to break it into portable lumps; these pieces are thrown into carts, and the carts, drawn by seven or more horses, convey their load either where it may be thrown into the sea or piled up in heaps at a distance. The roach-stone is not less hard and obdurate in its character, and requires blasting as a means of separating it into convenient masses. A circular hole, about five feet deep by three inches wide, is drilled in the rock, and into this hole is rammed a portion of gunpowder connected with a train on the outside. The train being fired, the powder explodes, and the rock becomes rent for several yards around the hole with vertical fissures. The masses of stone between these rents sometimes weigh fifty tons each; and to remove these is a long and laborious process. Rollers and jacks, worked by the hands of the quarrymen, are the only means adopted for removing them. Three of the jacks are placed against the mass to be removed, and the men commence to heave round the winches, cheering each other by a shrill cry of "High, boys, high!" It is only by the most minute shades of distance that the huge block can be moved at each effort; but it *is* moved, and the labour has been characterized as one of the most severe to which any body of men are ever subjected.

When all the superincumbent strata are thus cleared away, the quarrying of the real Portland stone (Fig. 650) commences. The bed of Portland stone is found to be fissured in various directions; and these fissures divide it into masses which facilitate its removal. By wedges and other contrivances the masses are loosened, and are by degrees removed out into an open spot of ground. Here a sort of council is held among the men; each piece of stone is examined as to its size and shape, to determine whether it is best fitted to make a shaft, a baluster, a pier-stone, or other form required by the builder, and when the decision is arrived at, the mass is brought to a rude approximation to that form by a heavy pick called a "kivel." The stone is weighed and the weight marked on it, together with the name or monogram of the proprietor. When the stone is ready, it is lifted on a rude sort of cart or truck with solid wooden wheels, and drawn by several horses to a central station, from whence it is conveyed to a wharf for shipment near the Chesil Bank.

All this work is very laborious, and the men engaged at it are a peculiar and strongly characterized class of men. They are in number about five hundred, and form a community among themselves; they are well-formed, muscular, strongly-featured, and intelligent men. When at work they wear a slouched straw-hat covered with canvas and painted black, a blue striped shirt, and white canvas trowsers. Their earnings in money are small compared with the hardness of their labour. Ten shillings per ton is fixed for the labour of raising the stone, but this includes the removal of all the superincumbent rubbish; and so vast is the rubbish in quantity, that three years' labour is required before a quarry of the good stone is bared and exposed to view. They receive none of the money until the freestone is actually raised, so that at the opening of a quarry they work for this long space of time without payment. During this period the agents and foremen keep small shops from whence they supply the men with the chief necessaries on credit. Taking the whole time together, including both the preliminary and the finishing operation, the rate of working is such as to allow about an average wages of twelve shillings a week to each man; but this average is reduced to eight or nine shillings by various casualties, such as weather, sickness, slackness of demand for stone, &c. The families of the quarrymen, however, eke out a life of tolerable comfort by many additions to their incomes. They grow corn, potatoes, fruit, and garden produce on little plots of ground rented at twenty or thirty shillings a year each: they have their own dairy produce, of milk, cheese, butter, and eggs; they obtain mushrooms, water-cresses, and a wild plant which makes a good substitute for arrow-root from the fields around them; they have good fishing at the neighbouring shores; and they make fuel out of dried cow-dung, as in Eastern countries. It is said to their credit, that the Portland quarrymen are among the most moral and best conducted persons in the British islands.

Of the operations subsidiary to quarrying, in respect to the working of stone, little need be said here. Blocks are sawn into pieces of the required form by long blades of iron without teeth, but which are made to act as saws by the employment of wet sand in the saw-cut. The long blade of the saw is fixed lightly in a frame, which is drawn to and fro by a sawyer sitting at one side or end of the block of stone. A vessel of water is so placed over the stone that a small stream can flow continuously into the saw-cut, and sand is conveniently placed for being drawn into the fissure from time to time. Other modes of working the stone will come under our notice while speaking of the smoothing and polishing of marble in a future page.

Timber employed for Houses and Furniture.

If we glance at the timber-trees which form the ornament of so many noble forests, we shall see that the greater part of them are employed either in building or in furnishing a house; and it is instructive to observe the diversities as well as the similarities between different countries in this respect, and not less so the means adopted for bringing the timber to market in countries ill-provided with roads.

In the forest districts of the Alps, of Germany, and of Norway, where the people derive a good part of their existence from the timber of their trees, the modes of transporting their produce to market are often highly curious. In many of these districts may be seen such a scene as that depicted in Fig. 651, where logs are floating down a stream, and where men are collecting them together so as to form a raft. In such cases the woodmen cut down the trees, hurl or roll them into the stream, and let them float down to the sea, to a lake or to any place where they can be conveniently disposed of. This is comparatively easy so long as the forest is not far from a stream; but when it is inland, or situated at a great height, or separated from a stream by a rugged and mountainous district, the ingenuity of the woodman is taxed to the utmost to devise means of transporting the timber.

One of the means adopted is to construct a slide down which the timber may run by its own impetus. Early in spring the woodmen set off to begin their business of cutting down the trees in the forest, perhaps many miles from their homes; they have to construct rude huts in which they live during the summer and autumnal months; and throughout the whole of this period they employ themselves in cutting down the noble trees which surround them. Every tree is classed according to its fitness for practical purpose, and cut up into logs; and the logs so accumulated are heaped up into huge piles. When the winter arrives, all these logs are transported down to some stream or lake by means of a slide or trough. This trough is usually constructed of six or eight fir-trees, placed side by side lengthwise, so as to form a semicircular gutter or trough, made smooth by stripping the bark from the trees. The trees are laid side by side and end to end, so as to form a trough of very considerable length, having a gradual descent, curving round the shoulders of mountains, spanning over valleys and yawning ravines by means of viaducts, and even perforating solid rocks by means of tunnels. There was one of these troughs constructed near the Alpine village of Alpnach, which was more than eight miles in length, and extended from an elevation of two thousand five hundred feet down to a lake. The trough was six feet broad and from three to six feet deep.

At the approach of winter, preparations are made for sending the logs of timber down these troughs. The logs are drawn, either by hand-sledges or by oxen, to the trough, and placed in it at the top; the snow is partially cleared away from the trough, and a few logs are thrown down to smooth the channel. Water is next poured upon it, which quickly freezes, leaving a surface of ice through its entire extent. The logs, placed on the upper surface of this slippery trough, descend immediately, slowly at first, but with almost inconceivable velocity as their momentum increases. Sometimes the trough terminates in the brow of a precipice, and the log in such case leaps over into the stream beneath with tremendous force, dashing and foaming in the water with a noise of thunder. Professor Playfair, who described the arrangements at the Slide of Alpnach, says, that when the operations were to begin, "workmen were posted at regular distances; and as soon as every thing was ready, the workman at the lower end of the slide cried out to the one above him '*lachez*' (let go). The cry was repeated from one to another, and reached the top of the slide in three minutes. The workman at the top of the slide then cried out to the one below him '*il vient*' (it comes); and the tree was instantly launched down the slide, preceded by the cry, which was repeated from post to post. As soon as the tree had reached the bottom, and plunged into the lake, the cry of '*lachez*' was repeated as before, and a new tree was launched in a similar manner. By these means a tree descended every five or six minutes." The velocity with which the trees descended is almost inconceivable: the descent of nine miles was usually made in six minutes, but in wet weather it was frequently effected in three, being at the rate of one hundred and eighty miles an hour! Perhaps the best way of conveying an idea of this amazing velocity is to state that Professor Playfair found it quite impossible to give two successive strokes of his stick to any, even the longest tree, as it passed him.

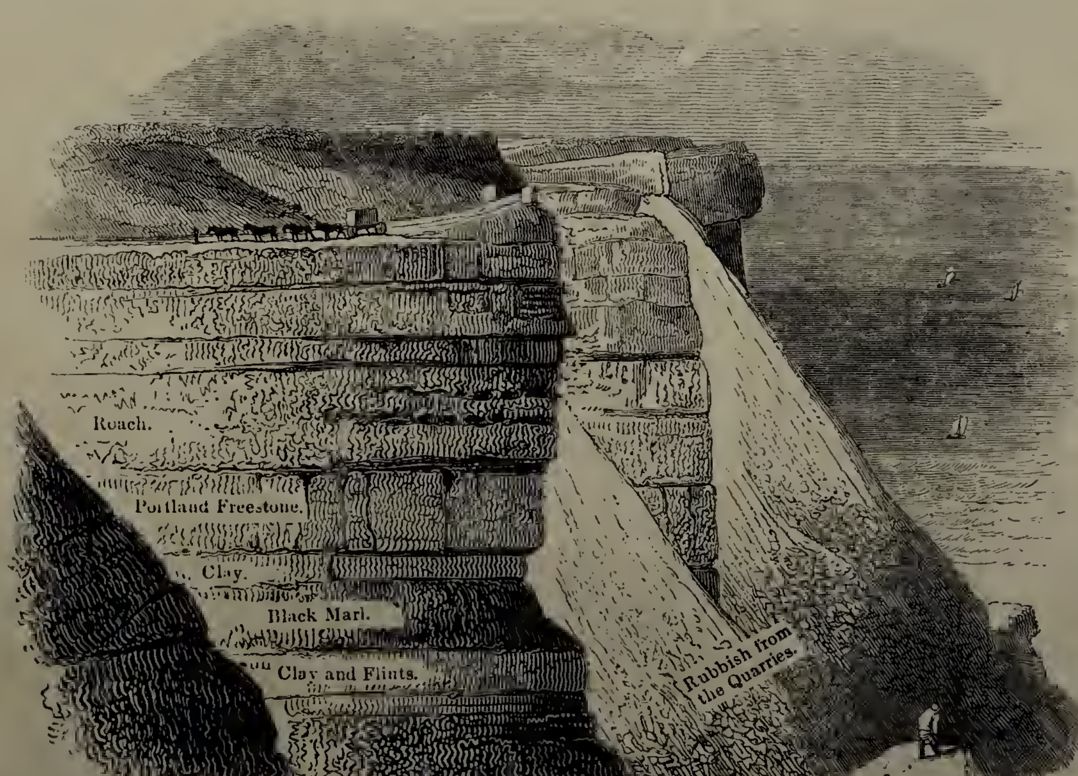
An interesting description has been given of the mode of bringing timber to market in the heart of Russia. A Russian proprietor who wishes to dispose of the timber on his property, having completed a bargain with a St. Petersburg merchant, sets his peasantry to work in selecting, felling, and dragging the trees from the forests to the lakes and rivers. This work generally takes place during the winter months, in order that everything may be ready for floating the timber to the capital as soon as the ice in the rivers and lakes breaks up. As the ground is generally covered several feet deep with snow, and as the trees judged to be sufficiently large and sound for the market lie widely apart, the workmen and others employed in selecting them are compelled to wear snow-shoes, to prevent them from sinking in the snow. When the trees are found, they are cut down with hatchets, and the heads and branches lopped off. The trunk is then stripped of its bark, and a circular notch is cut round the narrow end of it, to facilitate the fixing of the rope by which the horses are to drag the trunk along; and a hole is made at the other end to receive a handspike to steer the log over the many obstacles that lie in its way. Many of these trees are seventy feet in length, and of proportionate diameter; and they are drawn by four, five, to nine horses each, yoked in a straight line one before another, since the intricate narrow paths in the woods will not permit of any other arrangement. One man mounts upon the leading horse, and another upon the middle one, while others support and guide with handspikes the large and distant end of the tree, to raise it over the elevations of snow, and make it glide smoothly along. The conveyance of these large trees, the long line of horses, and the number of peasants accompanying them through the forest, present a very picturesque appearance. In many cases the trees are brought nearly a thousand miles before they are delivered to the merchant; and they generally remain under his care till another winter, to be shaped and fitted for exportation in such a manner as to take up as little room as possible on shipboard; so that this timber does not reach the foreign consumer till two years after it has been cut down. When the trees are delivered to the merchant, they are carefully examined to ascertain their soundness; and for this purpose a hatchet is struck several times against them, the emitted sound affording the means of estimating the soundness of the tree; those which are defective, and which are called "braake," constitute about one-tenth of the whole. The trees are not conveyed from the forest the whole way to St. Petersburg by horses, but only to the margin of some stream or lake, from whence they may be floated down to the capital.

The "lumbering parties" in North America fell and

651.—Timber Rafts of the Tyrol.

650.—Portland Quarry.

653.—Timber: the Norway Fir.



649.—Strata at the Portland Quarries.

652.—Timber: The Oak.

655.—Timber: the Larch.

654.—Timber: the Silver Fir.

656.—Timber: the Horse Chestnut.

660.—Timber: the Mahogany-Tree.

661—Transporting Mahogany at Honduras.

657.—Timber: the Yew.

658.—Timber: the Cedar.

659.—Timber: the Alder.

tranship timber in a way combining in some degree the Alpine and the Russian methods. "Lumber" is a general name for timber in North America; and a lumbering party is a sort of joint-stock company of woodmen who procure timber from the depths of the forest, and bring it to market. The parties cut down the trees during the summer months, and divide or shape them according to the purposes to which they are to be applied. The scene of operation is selected, if possible, near the bank of some stream which will both work a saw-mill and float the timber down to market. During the autumn the felled trees are cut into logs, or hewed with the axe into baulks and beams; and when the winter has arrived, and the ground become slippery by a coating of snow, the logs are dragged by oxen to the bank of the stream. Here saw-mills of a rude and temporary kind are erected to cut up the logs into planks; and during the winter this process is carried on. At the approach of spring, when the snows melt and the streams become freed from ice, preparations are made for floating the timber. If the stream be large, the timber is formed into a large raft; but if small, rafts of a few timber-logs are made. The timber sometimes floats down a distance of three or four hundred miles, being conveyed the whole distance by the natural power of the current; no attempt being made to manage the raft except to guide it among the windings of the stream. Some of the raftmen build rude huts for themselves on the rafts; but others are more careless, and live exposed to all the fluctuations of the weather. When the timber has been floated down to any great or considerable town, the rafts are taken to pieces, the timber sold, and the raftmen paid for their labour. A whole year's earnings is paid at once; and the men, who are a very rough and dissipated set, indulge themselves in rioting and indulgence, and then set off on foot to the forests, there to begin another series of yearly labours.

But the most striking examples of the floating of timber by means of rafts are presented on the Danube and the Rhine. The immense forests of southern and western Germany are, in most cases, within reach of some stream or other which flows into the Rhine, the Danube, the Rhone, or one of the large rivers; and in such cases the logs of timber, precipitated into the smaller streams by the troughs or by some other contrivance, are floated singly down these small streams until they reach the larger rivers, where they are made into rafts. Mr. Planché, in his 'Descent of the Danube,' says, "Below this bridge (at Plattning on the Danube) the raft-masters of Munich, who leave that city every Monday for Vienna, unite their rafts before they enter the Danube. They descend the Isar upon single rafts only; but upon reaching this point they lash them together in pairs; and in fleets of three, four, or six pairs they set out for Vienna. A voyage is made pleasantly enough upon these floating islands, as they have all the *agrémens*, without the confinement of a boat. A very respectable promenade can be made from one end to the other, and two or three huts erected upon them afford shelter in bad weather, and repose at night." The arrangements on the Rhine are described more at length in an 'Autumn near the Rhine.' A little below Andernach the Rhine forms a small bay or inlet, where the pilots are accustomed to unite together the small rafts of timber floated down the tributary rivers, and to construct enormous rafts, which are floated down the Rhine to Holland, and there sold. These huge rafts have the appearance of floating villages, each composed of twelve or fifteen little wooden huts on a large platform of timber. The raft, which is frequently eight or nine hundred feet long by sixty or seventy wide, is composed of several layers of timbers or trees placed on one another, and tied together, the whole drawing about six or seven feet of water. Several smaller rafts are attached to the large one, besides a string of boats loaded with anchors and cables, and used for the purposes of sounding the river and going on shore. The rowers and workmen sometimes amount to seven or eight hundred, superintended by pilots, and over the whole is placed a proprietor or manager, whose habitation is superior to the others. As the men live on board the raft, the arrangements for their comfort are very extensive. Pigs, poultry, and other animals are kept on board, and butchers accompany the troop. A well-supplied boiler is at work night and day in a kitchen built on the raft. The dinner hour is announced by a basket stuck on a pole, at which signal the pilot gives the word of command, and the workmen run from all quarters to receive their rations. The consumption of provisions is enormous; forty or fifty thousand pounds of bread, twenty thousand pounds of fresh meat, with a proportionate quantity of butter, salt meat, vegetables, &c., are demolished in the voyage from Andernach down to Holland.

Such, then, are some of the modes in which timber is brought to market. Generally speaking, fir, pine, or deal (for these are three names applied to pretty nearly the same kinds of wood) is the kind to which these operations relate; for no other sort is so extensively used in building operations as this. The appearance of the trees which yield several kinds of timber will be seen in the various cuts from Fig. 652 to Fig. 660. Of these, the wood of some is used more for ship-building than for house-building and of others more for the furniture of a house than for its construction. A few points of interest may call for a little notice in respect to some of them.

The *larch* is a tree whose timber has been brought very rapidly into use within the last few generations. It is very durable, tolerably clear from knots, little liable to shrink or to split, and pretty tough. The extent to which it has been planted in Scotland is astonishing. In the year 1730 the Duke of Athol planted about two thousand larch-trees on his estate in the Highlands, at first for ornamental purposes, but afterwards for the sake of the timber. The next duke conceived the idea of clothing the hills about Dunkeld with larches as a nursery of timber-trees; he had many difficulties to encounter, partly arising from scarcity of young plants, and partly from the clearance which the ground required before the planting could take place; the number he planted was about eleven thousand. His successor, Duke John, effected an amount of planting which has probably had few parallels in any age or country. From the year 1774 to 1826, a period of rather more than fifty years, he planted *fourteen million* larch-trees. At first this enterprising nobleman merely carried out the plans of his predecessor; but observing the rapid growth and hardy nature of the larch, he determined to plant it on the steep acclivities of mountains of greater altitude than any that had previously been tried. He enclosed a space of about thirty acres, on a rocky summit, and planted young larches among the crevices and hollows; while in other cases he substituted the larch where Scotch pines had previously been grown. Of the labours of the Duke in this important enterprise a writer in the 'Highland Society's Transactions' observes:—"His Grace planted, in the last years of his life, six thousand five hundred Scotch acres of mountain-ground solely with the larch, which, in the course of seventy-two years from the time of planting, will be a forest of timber fit for the building of the largest class of ships in her Majesty's navy. Before it is cut down for this purpose, it will have been thinned out to about four hundred trees per acre. Each tree will contain, at the least, fifty cubic feet or one load of timber; which at the low price of 1*s.* per cubic foot, will give 1000*l.* per acre, or in all a sum of 6,500,000*l.* Besides this, there will have been a return of 7*l.* per acre from the thinnings, after deducting all expense of thinning and the original outlay of planting. Further still; the land on which the larch is planted is not worth above from 9*d.* to 1*s.* per acre. After the thinnings of the first thirty years, the larch will make it worth at least 10*s.* an acre, by the improvement of the pasturage, upon which cattle can be kept summer and winter."

The felling and transport of mahogany at Honduras are interesting features in woodcraft. The finest trees are generally found in the most inaccessible situations; and therefore the employment is one of some labour. The felling season commences about the month of August; and at this time twenty or thirty persons form themselves into a gang to proceed on a mahogany-cutting expedition into the woods. One man is sent before them to hunt out the finest trees, sufficient in number to occupy the gang throughout the season. The men proceed to work, cutting the trees at a height of about ten or twelve feet from the ground, a stage being erected for the axe-man to stand on. When this is done, the men make a road along which they may drag the tree, and this often occupies twice as much time as the felling. In the first place the spot selected is as near as possible to a stream; in the next, huts are built to form a village in which the men may temporarily reside; the third, the selected trees are felled; and in the fourth, the intervening trees are cut or burned down so as to form a road to the stream. Unless the road from a tree to the stream be tolerably level and smooth, it is found to be impossible to drag a log along its surface; and it is for this reason that so much pains are taken in making a road. When the roads are ready, which occurs about the month of December, the felled trees are cut across into logs, from two to five logs being obtained from each tree; and the logs so cut are brought to the square form by the axe, in order that no useless additional weight may have to be drawn. After the rainy season of spring, and during the dry months of April and May, the logs are conveyed from the forest. To each gang of forty men there are six waggons or trucks, and as many oxen as can draw a large log of mahogany. The logs, by means of a temporary platform, are placed upon the trucks, the oxen are harnessed in front, and the cavalcade proceeds (Fig. 661). Twelve men drive the six waggons, twelve more load the waggons with the logs, and sixteen cut food for the cattle. The loading and carriage are effected during the cool of the night, splints of the pitch-pine being used as torches. By about the middle of June the rivers are sufficiently swollen to allow the logs to float down, the men following them in flat-bottomed canoes, and guiding them in safety. After floating down a distance of two hundred miles to Belize, the logs are landed on the wharfs of the merchants, and from thence shipped to England.

Bricks and Brickwork.

Here we come to another of the great classes of materials for building; one which is much more artificial in character than either stone or wood.

We have evidence in various quarters of the kind of brickwork constructed by the early nations of the East. The ruins of Babylon present abundant specimens of the bricks which were used in the construction of its buildings. The bricks so employed were either dried in the sun or burnt in a kiln; and a very fine sort of brick was employed to encase thick walls built of common bricks. It was on these fine surface-bricks that the inscriptions were made, which have been so often alluded to in works on Oriental antiquities. The clay of which they were formed appears to have been mixed up with chopped straw or reeds; when baked or dry, they were set in hot bitumen, sometimes in clay-mortar, and sometimes also in a fine lime-mortar.

In Persia the bricks are both sun-dried and baked. The sun-burnt bricks are made in wooden moulds, about eight inches long, six wide, and two and a half deep. The earth is tempered by treading with the feet, and is mixed with finely cut straw. While the bricks are in the mould they are dipped in a vessel of water mixed with chopped straw, and then smoothed by hand; the moulds are then removed, and in about three hours the bricks have sufficient consistency to be handled, when they are placed in rows one over another to become thoroughly dry. The baked bricks are made of earth and ashes.

In India some of the brick buildings, whatever may have been the period at which they were erected, seem to have been built of bricks not only fired, but formed with a skill which has rarely been equalled. Dr. Kennedy, in his 'Campaign of the Indus,' says:—"Nothing I have ever seen has at all equalled the perfection of the early brick-making which is shown in the bricks to be found in these ruins (ancient tombs near Tatta); the most beautifully chiselled stone could not surpass the sharpness of edge and angle, and accuracy of form, whilst the substance was so perfectly homogeneous and skilfully burned, that each brick had a metallic ring, and fractured with a clear surface like breaking freestone. I will not question the possibility of manufacturing such bricks in England, but I must doubt whether such perfect work has ever been attempted."

The Egyptians, the Greeks, and the Romans were all acquainted with the use of bricks in their buildings. When the Israelites were in bondage in Egypt, one of the tasks imposed upon them was the making of bricks; and these bricks, it has been supposed, were sun-dried, not burnt in the fire. Such bricks were used in the large walls which enclosed their temples, and sometimes in building pyramids. As to the Greeks, it has been supposed that they did not employ bricks in building until after their subjugation to the Romans; for no brickwork is found among the ruins of Greek buildings constructed before that time; but this point has been doubted by other inquirers. At all events the Greeks had names for different kinds of bricks, according to their sizes. They employed the term *doron*, "hand-breadth," and designated bricks as being *didoron*, *tetradoron*, or *pentadoron*, according as they were two, four, or five hand-breadths in length. Bricks were also made the half of these several sizes, to "break joint," as the bricklayers term it. The bricks used by the Romans in many buildings still existing are more like tiles than modern bricks: they are square, measuring from seven to twenty-two inches on each of the sides, and from one and a half to three inches thick; the colour being red. In other Roman buildings there are found beautiful small red bricks, some of which are triangular.

The size and form of the bricks made in England are well known; and we may now briefly describe the mode in which they are made. The clay for the bricks, being exposed to the action of a winter's frost after being dug, is mixed with fine ashes in the proportion of four parts of clay to one of ashes. When the ingredients are so far mixed as to form a black streaky mass, the mixture is removed in barrows to a pug-mill—an iron-hooped barrel, in which the clay is cut and worked about till perfectly amalgamated. The clay, as prepared by this kneading process, is placed upon a kind of bench at which the brick-maker or "moulder" works, where a boy or a woman cuts it into pieces somewhat larger than the capacity of the mould. This mould is about ten inches long, five broad, and three deep, so as to yield a brick which, after burning, shall measure nine, four and a half, and two and a half inches in its three directions; this being the size according to which the government duty has been regulated. The moulder dips the mould in sand, by which its inner surface becomes covered with a fine layer, and then strikes the piece of clay into the mould with such force and dexterity that all the angles and corners of the mould become filled. He then takes a smooth flat piece of wood, with which he scrapes off the superfluous clay, and disengages the brick from the mould by a gentle stroke on the back of the mould. The wet bricks, as liberated, are arranged in rows on

a long board, and when sufficiently dry to be handled they are turned, and subsequently piled up in loose walls or rows, thatched with straw to keep off the rain. In this position they are allowed to remain until they have become as dry as they can become in the open air.

The bricks so made and dried are burned in one of two methods—either in *kilns* or in *clamps*. The *kilns* are structures about twelve feet high, in which the bricks are placed on flat arches. When thus arranged, to the number of about twenty thousand, they are covered with old bricks or tiles, and a moderate fire kept up till the bricks are rendered as dry as possible, which usually occurs in two or three days. The mouth of the kiln is then filled up with pieces of brick and clay, leaving room only to introduce a single faggot at a time. The fire is then kindled to a fierce heat, and so continued till the bricks are burned.

In the method of burning by *clamps*, the bricks are piled up in long rows, between every two of which is strewed a quantity of cinders, to the thickness of three inches. Openings are made between the bricks at various parts, which are similarly filled with cinders; and cinders are also strewed over the top. A fire-place is formed at one end, and a fire lighted, the heat from which gradually kindles the cinders, throughout the mass, and thus burns or bakes the bricks. The *clamp* is sometimes three months in becoming thoroughly heated.

Modern ingenuity has devised many modes of applying machinery to the making of bricks. In one machine so employed there are several moulds arranged on a horizontal wheel, the rotation of which causes the moulds to pass successively under a hopper or receptacle, from which they receive their quota of tempered clay. As the moulds advance they pass under a knife, which is so adjusted as to cut off the surplus clay. The bottom of each mould is loose, and by an ingenious arrangement is made to rise in the mould as the wheel revolves; so that, by the time one revolution of the wheel is completed, the brick is lifted completely out of the mould. The bricks thus elevated are, by a piece of mechanism, transferred to an endless band, and conveyed to any desired spot. After the moulds have been used in this way, they pass under a sieve to be sanded before being again filled with clay. There is also an arrangement of mechanism by which the proper quantity of clay is forced into each mould as the wheel rotates.

In another kind of machine the clay is prepared by passing between two large cylinders, placed horizontally at a distance of half an inch apart; by which means any small stones or hard substances are crushed and broken. The clayey mass, after being tempered or kneaded in a mill, is made to pass between two cylinders rotating in contrary directions, by which it is brought to the state of a flat cake suitable in width and thickness to the brick about to be formed. This long riband of clay next passes on to an endless web, which carries it to a third cylinder. There are cog-wheels attached to the machine, whose cogs are so regulated that, when ten inches of brick are formed, a wire descends and cuts off that portion from the rest of the piece, and conveys it to an endless web. Some such machine as this is now employed for making draining-tiles for agricultural purposes.

How these bricks, when made, are built up into lofty and durable walls, is in some degree known to most persons. The walls of brick buildings vary greatly in thickness according to the strength required for them, being in some instances only "half brick," or four and a half inches in thickness; and in some extreme cases as much as four bricks, or three feet thick. The mode of connecting the bricks together, so that the joints shall not occur at places likely to weaken the structure, is called the "bond;" and there are several varietes of this bond. For instance, "English bond" consists of having the bricks laid lengthwise along the length of the wall, and crossed with others laid with their breadth along the wall; the former of these layers are called "stretching-courses," and the bricks forming them "stretchers;" the latter are "heading-courses," and the bricks "headers." Another kind, called "Flemish bond," consists in laying a "header" and a "stretcher" alternately in the same course. The "herring-bond" is formed by placing the bricks at an angle of forty-five degrees, and reversed in the alternate courses. "Garden-wall bond" consists of three stretchers and one header in nine-inch walls. In all of these kinds of bonds, it is customary so to place the bricks that two joints shall not occur perpendicularly the one over the other.

In forming arched work, the arrangement of the bricks requires much additional care. In forming such an arch, for instance, as that in Fig. 662, so common over the windows of London houses, each radiating line of bricks is wider at the top *a* than at the bottom *b*; and the bricks require to be brought to the proper slope by means of a mould or gauge, seen at the lower part of the cut, on which there are marks *a*, *b*, to guide the workman in his progress.

To detail all the minute particulars attended to by the workman in the management of these matters is of course out of the question here: the "bond" or mode of jointure, the cement or mortar by which the fixity is attained, the care taken in observing a vertical position in the arrangement of the bricks, and the mode of connecting the work of the carpenter with that of the bricklayer—all call for the exercise of skill which, though rough in its character, is often not without neatness and finish. Sometimes, when buildings are intended to display a stone frontage, and when stone is too expensive to form the main substance of the structure, the walls generally are formed of brick or of rubble, and are cased externally with a layer of stone called *ashler*. The slabs of stone used for this purpose are generally from four to six inches thick. "Plain ashler" is that kind in which the surface of the stone is smooth; while "tooled ashler" is that in which the surface of the stone exhibits a series of narrow parallel flutings; a third kind, called "rusticated ashler," has an intended surface, produced by slightly cutting into the stone at the sides of two or more joints of each stone. Most of the public buildings in London in which stone is used present specimens of plain ashler; the basement stories often exhibit the tooled ashler; while many buildings, such as Whitehall Chapel, Somerset House, the Bank of England, and St. Paul's, have a good deal of rusticated ashler, of which the general appearance is sketched in Fig. 663.

While speaking of brick houses, it may be well to notice a very remarkable art which the Americans have put in practice, having for its object the entire removal of a house from the place where it was built, without any serious injury to the house itself. Figs. 666 and 667 represent some of the means adopted for carrying out this object.

An eye-witness to the operations which he describes, gives the following account of house-removals at New York (in 'Penny Magizine,' No. 661):—"Chapel-street, in New York, was widened by order of the corporation; many of the houses were moved back, and some pulled down. At the corner of Chapel and Leonard streets stood a large and strong brick building used as a blacksmith's workshop. This, lying in the way of the improvement, had to be removed. It was sold by auction, and was purchased very cheaply by a person who owned a small house adjoining it in Leonard-street, with some ground behind it. The speculative purchaser first moved the small house in Leonard-street beyond the extremity of the blacksmith's shop, and turned its front towards Chapel-street; he then moved back the blacksmith's building the required number of feet, and brought it on a level with the small house previously moved. Out of the old workshop he formed three handsome three-story houses, with shops, and made additions to the small house, so that the whole now present a line of four houses. In a more recent improvement, Centre-street was widened and extended, in order to join a main thoroughfare by the City Hall. Many houses were pulled down, and carried back as in other instances; but there was a well built brick house that stood completely across the proposed roadway. There was not sufficient room on either side to receive it wholly; so the ingenious proprietor, rather than sacrifice his house, conceived the idea of dividing it from top to bottom through the three floors; this he actually accomplished; and the two distinct parts were conveyed to opposite sides of the street, in which state I saw them before the chasms in the walls had been supplied. He then perfected them, and they form now two separate though narrow buildings. The cost of moving a moderate-sized brick dwelling is about one hundred dollars, very considerably less, even with the new brickwork, than the expense of pulling down and rebuilding, besides saving much time. A Mr. Simeon Brown, of New York, is said to have been the projector of this peculiar and useful operation; he died, I believe, only a few months since."

The mode of conducting this very curious operation is as follows:—In the building to be removed (which must either be a detached one, or part of a block the whole of which is to be removed), corresponding openings are made in each of the end walls just above the ground, sufficiently large to admit the insertion of beams about a foot or fifteen inches square, which project about two or three feet at each end, and are placed at intervals of about four feet from each other—these beams are marked 1 in the engraving: the projecting ends rest on blocks of wood fixed firmly in the ground, clear of the walls. When the beams are placed, wedges are driven between their projecting ends and the fixed blocks, in order to drive them up tightly against the upper part of the wall, thus supplying the place of the bricks knocked away, and supporting the weight of the walls. This done, the foundation of the end walls may be removed, the intermediate brickwork taken away, and a clear space left for further operations. The same process is then pursued with the front and back walls, the beams (2) passing below and across those first laid, and resting like them on blocks outside the walls. The foundation being now wholly laid bare, the two sets of timber are forced closely up to each other and to the brickwork by upright screws placed in the ground beneath them (3). This operation relieves the blocks, on which the projecting ends rested, of the weight of the house, and they are taken away; the house now resting entirely on the timber framework, sustained by the screws, the ground beneath is now dug away, and a set of fixed slides (6) are placed exactly where the foundation of the end walls had previously stood; on these slides, in which deep grooves are cut, are placed a set of cradles (5) similar to those used in ship-yards, which have a projection or feather corresponding with and intended to move in the grooves of the slides, both being previously well greased; and between these cradles and the timbers (2) the beams (4) are inserted at right angles with both pieces of wood, and wedges are then driven in at various parts to tighten the whole in order to bring the entire weight of the building on to the cradles, and consequently upon the slides on which they rest. 7, 8, and 9 show some of the ways in which these strengtheners are applied. When this is effected, the supporting screws can be withdrawn, and the whole of this complicated framework is so well fastened together, that there is little danger of the edifice it supports getting deranged in the act of moving. The slides are laid continuously to the exact spot in which the house is to be deposited, where, in general, a new foundation has been prepared for it. The screws are then placed horizontally against the cradles, and being made to act together, the cradles with their burden move along the slides at the rate of three or four feet per day to the place of destination. When arrived there, by inverting the process, the timbers are withdrawn one by one, and the house is permanently fixed in its new situation without injury to itself, and frequently without even removing the furniture.

Although the buildings themselves are of a different class, there is a remarkable circumstance connected with lighthouses which bears on the present point—viz., the entire removal of a lighthouse to a different spot from that on which it was built, without injuring the structure. The circumstances were as follow:—In the year 1803 a lighthouse was built on the northern pier at Sunderland. It is wholly composed of stone; its form is octangular, fifteen feet in breadth across its base, nine feet across at the top, and about eighty feet high to the top. During the month of May, 1841, a plan was under the consideration of the Commissioners of the river Wear to pull down this lighthouse, and to re-erect it on the eastern extremity of the pier—a spot distant five hundred feet from the former locality. Mr. Murray, a civil engineer, however, conceived the practicability of removing the entire lighthouse without destroying or endangering it. According to the plan proposed by him, "the masonry was to be cut through near its foundation, and whole timbers were to be inserted, one after another, through the building, and extending seven feet beyond it. Above and at right angles to them, another tier of timber was to be inserted in like manner, so as to make the cradle or base a square of twenty feet; which cradle was to be supported upon bearers, with about two hundred and fifty wheels of six inches diameter, and was to traverse on six lines of railway, to be laid on the new pier for that purpose. The shaft of the lighthouse was to be tied together with bands, and its eight sides supported with timber braces from its cradle upwards to the cornice. The cradle was to be drawn and pushed forwards by powerful screws along the railway, on the principle of Morton's patent slip for repairing vessels." The only important deviation from this proposed plan was in the substitution of a windlass and rope, worked by thirty men, for the screws. By making openings transversely through the masonry near the bottom, and by inserting stout timbers through them, the structure acquired by degrees an artificial bottom formed of timber; and this timber flooring, being moved along a railway by means of wheels, was the means of transporting the bulky burden to its new locality. It is said that there was not a crack nor any appearance of settlement throughout the whole building after the removal.

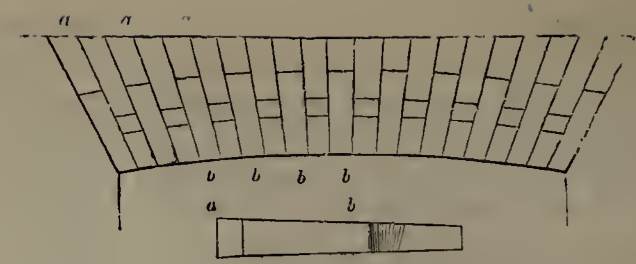
Slates and Slating.

Another branch of mechanical art contributing to the building of a house is that which relates to the slates, tiles, and thatch—these are the three chief varieties; to these we may devote a little attention.

Slate is the production of certain quarries situated in various parts of Britain, but especially in Wales, Cumberland and Scotland. The rock is procured in tabular masses by means of large wedges, and is then subdivided by smaller wedges into thinner portions, the natural cleavage of the rock being such as to facilitate this operation. The pieces are roughly squared with a sort of axe, and are sorted according to their sizes for roofing. Some are three feet and a half long by two and a half wide, while others are much smaller, according to the kind of roofing for which they are intended.

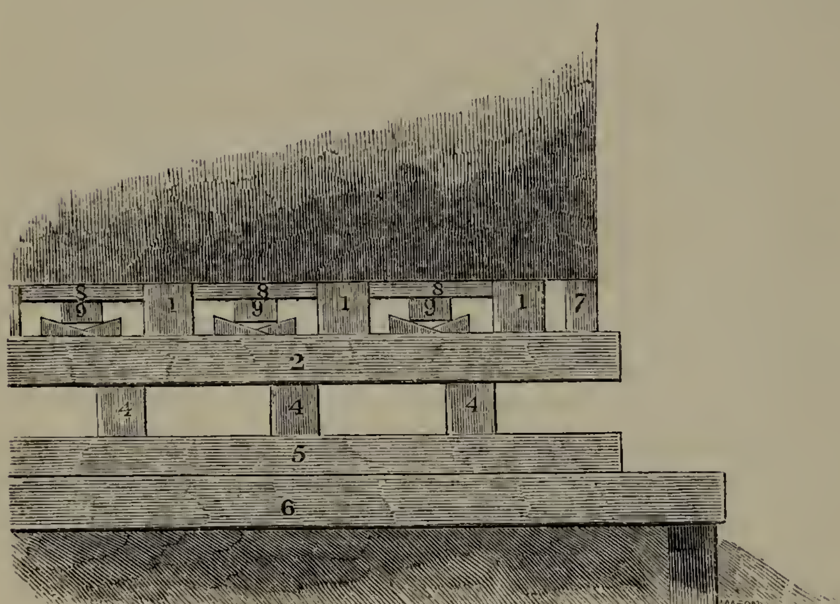
Near Bangor the slate-quarries occupy the greater part of the distance from Snowdon to the Menai Straits. Upwards of two thousand men are employed in these quarries; and the proprietor is said to gain from thirty to forty thousand pounds per annum by them. In another slate-quarry, in Cumberland, situ-

665.—Modern Egyptian Plasterers at Work.

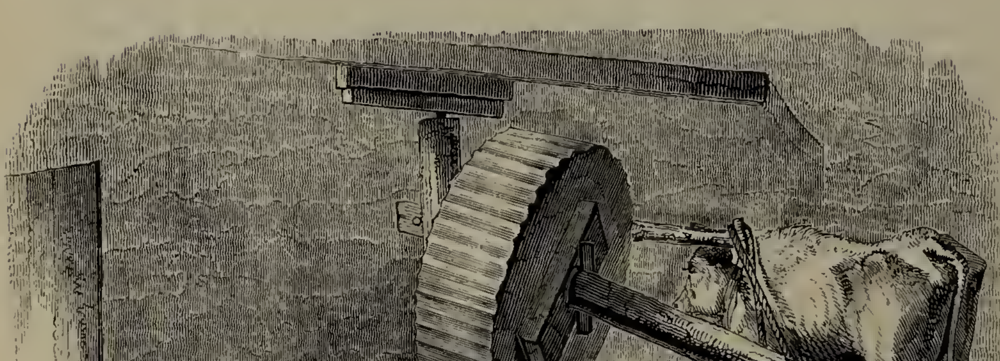


662.—Arch formed in Brickwork.

663.—Ashler-work.



667.—Mode of removing Houses in America.

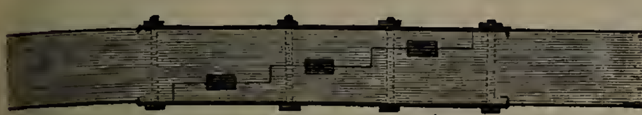


664.—Fine Lime Grinding-mill at Cairo.

666.—Mode of removing Houses in America.

669.

670.



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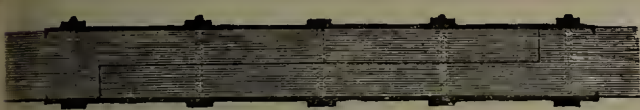

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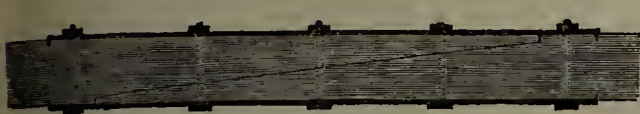

673.

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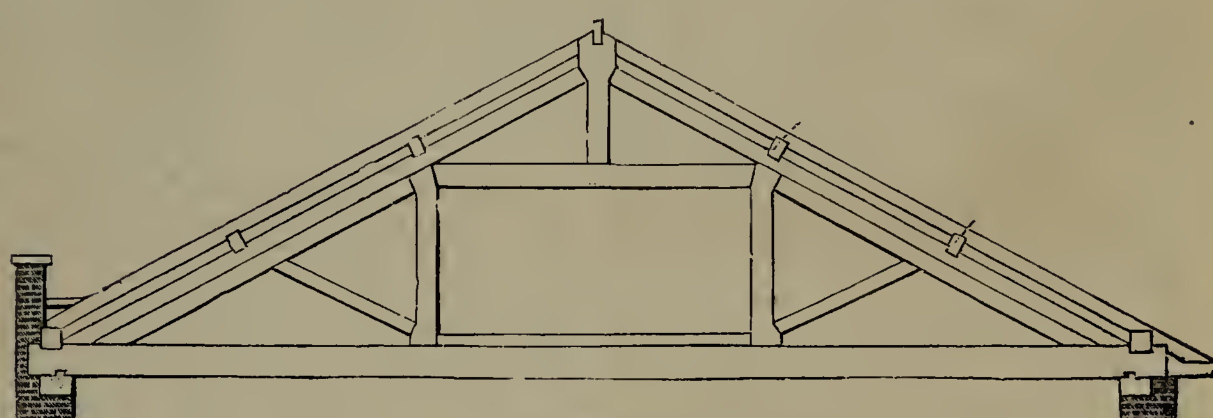
669 to 674.—Modes of lengthening Timber.

676.—Interior arrangement of a Turkish Bazaar.



675.—Carpentry of Roof.

677.—A Shop at Cairo.

668.—Thatching in Normandy.

ated near Buttermere Lake, about two thousand feet above the level of the water, the difficulty of access is so great, that the workmen take provisions enough for a whole week, and sleep in temporary huts on the summit of the mountain: they are generally involved in clouds during winter, and are often completely blocked up by the snow.

At a distance of about twelve miles from Bodmin in Cornwall are the celebrated slate-quarries of Delabole, three in number. When viewing one of these from an elevated spot at hand, "the ear is assailed," to use the words of an eye-witness, "by the reverberating crash of explosions proceeding from the pit. The waggons are seen advancing along the trams propelled by men, steam-power having previously brought them up the incline; the splitters are actively taking off the load as brought to them, and the produce of their industry appears on all sides in long piles of roofing-slate ready for use. From this point there is a striking view of the lower quarry, its machinery, incline, &c.; the men studded over a vast heap of débris; beyond you look out over an undulating country, chiefly in pasture, the rough ridge of Beam Willy rising in the distance. Standing at the edge of the pit a visitor might almost suppose himself at a railway station, from the many lines of trams, turning platforms, &c. Looking over the boarding fixed there for security, a singular spectacle presents itself. This pit is three hundred feet deep, and its surface at the bottom about three-quarters of an acre. The sides are precipitous, but of unequal height, the bottom apparently level; on it are working about a hundred quarrymen. Bending down to their labour, and clothed in a whitish dress, their diminutive appearance at that depth affords a resemblance to sheep scattered over a deep hollow."

The working arrangements are thus conducted:—The rock is first blasted, and the masses loosened by this means are divided in the pits into blocks about a foot in thickness: these again, when brought to the surface, are further split by chisels and mallets into the various sizes required. Roofing-slate is squared up by hand, the workman holding the slate on a thin piece of iron fixed edgewise in a block of wood, and striking it with a kind of hatchet called a *gix*. The squared slates are arranged in long rows, those of the same size being placed together. Between every ten dozen a piece of rough slate is placed to facilitate counting.

At the Delabole quarries the slate is conveyed to the sea side in waggons drawn partly by oxen and partly by horses, but railway transit will probably supersede all other before long. Seven or eight hundred people are employed, of whom about one-tenth are women; the men earn about fifteen shillings a week, and the women, who wear a kind of waggoner's frock to keep the other parts of their dress clean, about six shillings. The labours of the workpeople are paid by piece-work, or "tutwork" as it is called. There are about twenty sub-divisions of employment, in all of which the same system is carried out. The people are paid once a month. A market is held on the spot twice a week, once for meat and once for corn, at which they purchase their provisions. The quarrymen are a well-conducted body; various rules are laid down for the observance of good conduct, and fines inflicted for non-compliance: these, after paying for the services of a medical man, are divided among those who have not subjected themselves to penalty.

The operation of slating the roof of a house is by no means an elaborate one. The slater, in the first instance, dresses the slates by squaring the sides and bottom end of each, so that they may match closely with each other and form regular lines or "courses" along the roof. The upper end of each slate is then perforated with one or more holes by means of a sharp pointed instrument. The slater, in laying them on, commences at the eaves of the roof. Having laid laths across the rafters at proper distances, he places a line of slates side by side, and another row upon them, in such a way that the seams of the lower row may be covered by the upper; then the subsequent rows are laid on one after another, each slate being nailed down to the wood-work beneath, and being made to overlap the row previously placed; this overlapping is called the "bond," and on its extent or amount depends much of the strength of the workmanship.

Various kinds of Roof-coverings.

The kind of roofing made with *tiles* is a cheaper substitute for slating. The tiles are composed of a material, and made in a manner, which place them in an intermediate position between bricks and coarse brown pottery. The peculiar form given to them is necessary as a means of preventing rain-water from penetrating between and beneath them. Each tile is convex at one part of its width and concave at the other, and this arrangement is such that the convex part of one tile laps over the concave side of the one placed next to it.

Many other modes of roofing houses have been more or less adopted, such as with iron, zinc, asphaltum, fir, and even paper. Iron, used in thin sheets, is becoming much employed for this purpose in large buildings, on account of the extensive surfaces which may be produced without any considerable weight. By making the edges of the plates lap slightly over each other, the roof may be made rain-proof with very little difficulty, and may be nearly flat. The following account was given in one of the scientific journals a few years ago, of the roofs now often made in Russia:—"Sheet-iron coverings are now universally made use of in all new buildings at Petersburg and Moscow. In the case of a fire, no harm can come to a house from sparks falling on a roof of this description. The sheets of this iron-covering measure two feet four inches by four feet eight inches, and weigh twelve pounds and a-half avoirdupois per sheet, or one pound five ounces each superficial square foot. When the sheets are on the roof they measure only two feet wide by four feet in length: this is owing to the overlapping. They are first painted on both sides once, and, when fixed on the roof, a second coating is given; the common colour is red, but green paint, it is said, will last twice the time. Small bits or ears are introduced into the laps for nailing the plates to the two-inch square laths on which they are secured."

An ingenious and valuable mode of employing sheet-iron for roofing is in the *corrugated* form, that is, the iron is passed through a machine which imparts to it a number of parallel channels or grooves. These give to the iron somewhat of the strength of the arch, while at the same time it furnishes channels down which rain-water may flow. When such sheets are bent so as to present a general convex surface uppermost, they are capable of being used to roof very large buildings: instances have been known in which roofs two hundred and twenty feet long by forty wide have been constructed in this manner. In such a case, the sheet-iron is not merely a *covering* for the roof, it forms the roof itself, lighter than any other which can be constructed.

Zinc is now frequently used as a roof-covering; it is not so heavy as lead, and not so soon acted on by the atmosphere as iron. Another contrivance is to give to sheets of iron a thin coating of zinc, by means of galvanic agency, whereby they acquire the double advantages belonging to both the metals singly.

Asphaltum is employed occasionally for terraced-roofs, and others which have rather a flat form. The material, which is a kind of bituminous earth, is brought to a melted state, and then poured out while hot upon the surface which is intended to be covered. A few years ago a "flexible asphaltic roofing" was made the subject of a patent. This consists of asphaltum mixed up with the refuse "felt" from hat-manufactories, compressed into thin plates; it is very light and thin, and is laid on as a roofing in the same manner as slates.

Wood is employed as a roof-covering in many country districts, where this material is very abundant, and others are less attainable at a cheap price. The timber is first cut to the required size, and then steeped for a fortnight or three weeks in a pond of lime-water, by which the fibre of the wood becomes to a certain extent shielded from decay. In many foreign countries roofs are made of trunks of trees cut in two and hollowed within; one row is laid down side by side, with the concave side uppermost; another is laid above them, with the convex side uppermost, in such a way that the joints of the lower layer may be covered.

One kind of material for roofs, which may appear not a little singular, is *paper*. Mr. Loudon introduced the use of it for cottages and farm buildings many years ago at his model farm at Tew Lodge in Oxfordshire. The mode of proceeding is as follows:—Pieces of wood called "couples" are placed across the building from wall to wall, rising slightly to obtain a descent for rain-water. On the couples are placed horizontal rafters, the distance between the couples being from five to eight feet, and between the rafters about eighteen inches; the couples are nailed to the wall-plate, and the rafters are nailed to the couples. On the rafters are placed a regular surface for the paper, formed either of thin pine boards laid side by side, or close copse-wood hurdles plastered over, or common plaster laths. The paper used for these roofs is of a common coarse quality, and is immersed, sheet by sheet, twice over, in a cauldron containing a boiling mixture of tar and pitch. When dry these sheets are nailed down in the same manner as slating, being made to overlap each other. On the paper, when all nailed down, is applied a layer of hot composition made of tar, pitch, whiting, and charcoal; and while yet wet, a little sand or dust is sprinkled on, to shield the composition from the too great action of the sun. Mr. Loudon, in more than one of his works, has expressed himself very favourably of this kind of roof. Churches and warehouses have been roofed in this way; but it certainly would seem to be rather too combustible a material to form the roofing of houses where fires are kept.

Thatching, as is well known, is in country districts one of the most general modes of roofing a house. According to an account given in one of the Highland Society's publications, the proceedings are conducted in the following manner:—In laying on the thatch the thatcher stands upon a ladder resting upon the sloping conical roof of the rick (we select a rick as exemplifying the more simple kind of thatching), as near as he can to the eaves, and lays on the thatch in handfuls, from sheaves placed within his reach. He thrusts the inner end of his handful of thatch, gathered into a neck or wisp, into the butts of the sheaves, and spreads out the lower ends like a fan, overhanging the eaves; then covering as much of these as he can reach at arm's length, he works upwards, crossing each successive handful to overlap that immediately below; and he thus covers the roof in triangular portions till he has gone round the whole backwards, that he may avoid treading on his work. When he has reached the top of all, he lays a considerable thickness of short straw upon the crown, over which a straw rope is carried perpendicularly, dividing the roof into two equal sections: he then covers this topping of short straw with long thatch drawn to a point at the summit, and ties the upper end of this with a small straw rope into a peak, giving this last part the appearance of an umbrella. With the aid of two assistants on the ground, while he remains aloft on the ladder, so as to be able to reach the top with his hands, the thatcher now places a number of well-twisted ropes of tough oat-straw to lace down the cover and secure the thatch; these embrace the roof obliquely, and are fixed below, either to the butts of the sheaves or to a belt-rope firmly bound round the body below the eaves.

The thatching of a square rick is somewhat differently effected from that of a round one; but the thatching of sheds and buildings is more carefully conducted than any other. In this latter case the straw is prepared in the same manner, but the ends of the handfuls, as they are put in the lathed roof, are kept down by means of long rods, which are tied to the laths of the roof by means of strong tarred twine. A much thicker coat of straw is put on; and rye-straw, which has a solid stem, is preferred, as being more lasting, and less liable to be filled with water than hollow straw. Instead of straw ropes split-willow is used, and the rods which are inserted are much nearer each other and more carefully secured. Fig. 668 represents the mode of thatching adopted in Normandy, differing in some of its details from the English and Scotch method.

Thatched cottages, though often presenting a picturesque appearance, are subjected to inconveniences which materially lessen the advantages of this mode of roofing. Insects are generated in the thatch, from whence they find their way into the house; slugs and snails are also harboured in such houses. Mr. Loudon, in depicting a thatched cottage, says, "Such cottages have perhaps the gable end covered with ivy, the chimney tops trimmed with Virginia creepers, and the windows overshadowed by roses and jasmines. The ivy forms an excellent harbour for sparrows and other small birds, which build there in quantities in spring and early in summer, and roost there during winter. In June, as soon as the young birds are fledged, all the cats in the neighbourhood are attracted by them, and take up their abode on the roof of the house every night for several weeks, the noise and other annoyances caused by which we need only allude to."

Terraced Roofs of the East.

When we look at the construction of oriental houses, we find that the sloping roofs common in our own country are not much there met with: the fineness of the climate enables the inmates to pass much of their time on the house-tops, and the roof must consequently be flat instead of sloping, to afford the requisite facilities. Flat roofs require considerable care to render them fitted in construction for this purpose, and hence the oriental builders pay a good deal of attention to this branch of their art. The use of plaster, or cement, or mortar, or stucco (whichever name may be the most appropriate), is well known to the Egyptian and other oriental nations.

With regard to our own country, as compared with these, the use of terraced roofs is too limited to constitute an object of much importance. Some buildings in London have roofs formed of thin tiles embedded in fine cement without sand, and sometimes such roofs are covered first with a layer of gravel and then with one of earth. The plaster made in this country is of varied quality, according to the purpose for which it is intended. As a cement for brick-work, for instance, the plaster or "mortar" employed consists of quick-lime newly burnt from grey limestone, mixed with clean river sand, and worked up with water to the consistency of a stiff mass, which may be used with a trowel. When the walls of a room are to be coated with plaster as a foundation for some kind of decorative surface, the materials employed are somewhat different; for the coarse or under coating, cow-hair is mixed with the plaster to make it bind or adhere better, the plaster being laid upon a brick surface or upon a row of wooden laths, according to the nature of the work. If the plastered surface is to be exposed to view, without a covering of paint or paper, a layer of finer plaster is applied to the coarser layer beneath. The "cements" now employed are very numerous, and are generally selected for the quality of drying to a state of great

hardness, which hardness they will in some cases retain even under water.

But to return to oriental countries. There are many passages in the Bible which allude more or less to these matters. For instance, there is a passage in the book of Ezekiel relating to "untempered mortar," in reference to which Dr. Kitto makes the following remarks:—The Targum and Vulgate seem to understand this, not of plaster, but of the cement used in uniting the materials of the wall, rendering it 'clay without straw'—clay and straw, well mixed together, being correctly understood to have been the common cement of eastern buildings as it still is in the East. If this view be correct, it will of course imply that the wall was not built with wet cob, which requires no cement, but with dry cob, a clay and straw worked well together, and formed into masses, which are dried before employed in building, or else common new-dried or kiln-burnt bricks, or even stone. We rather incline to this view of regarding the 'mortar' here rather as cement than plaster. However, there is no reason to question that the Hebrews did at least sometimes plaster their walls. The most common in the East is made with the same materials as the cob-walls, new-dried bricks, and mortar; namely, clay and straw mixed together—the straw, such as they give to their cattle, chopped and beaten small, and serving the same purpose as the ox-hair which our plasterers mix with their plaster. This, to be good, requires to be well-tempered, which is generally done by long continued treading or beating. This is much used for the exterior of walls of humbler materials, but it will only do for dry countries, as the rain acts upon it very much, causing it to peel off, or else wearing it off, whence the prophet mentions an 'overwhelming shower' as the agent of its destruction. We have seen the *interiors* even of houses above the common, with no other plastering than this. Lime is, however, sometimes mixed with the clay and straw, and for certain purposes, such as the external coat of an interior plastering, simple lime plasters, such as our own, are sometimes used. When lime is largely used alone, or in a large proportion with certain earths, the tempering is usually performed either by beating with sticks, or by the turning of a wheel or roller, in much the same manner that our brick-makers prepare their clay. This work is, as in the parallel case, done by a horse or other animal. It would be to little purpose to mention all the materials and preparations of plasters for different applications, such as the coating of walls, the covering of the terraced roofs, and the lining of baths, tanks, and pools. Some kinds, generally used in a semi-liquid state, set very hard, and last long; and it is well understood that great pains must be taken to temper that required to resist wet. In the way of tempering, perhaps nothing affords a stronger manifestation of persevering and patient labour than the long-continued and repeated beatings to which the orientals subject the plaster (of lime, ashes, and straw) which is more especially intended to resist wet, and which does most effectually answer that purpose." Two of the modes of tempering above alluded to are sketched in Figs. 664, 665.

While on this subject, we may allude to a rather lengthened controversy as to the meaning of a particular passage in St. Luke's Gospel, evidently connected with some style of oriental house-building different from that to which we are accustomed. It is that in which the palsied man, unable to be carried through the crowd to our Saviour, is said to have been "let down through the tiling" from the house-top. In considering this passage, most commentators bear in mind that eastern houses have frequently an open court surrounded with buildings; but the modes of applying this fact are very various. Dr. Shaw suggests that, when many persons are congregated in the central court an awning is frequently spread over it to shield the people from the heat of the sun; and he supposes that the removal of this awning, sufficient to allow the couch of the sick man to be lowered into the court, might answer pretty nearly to the passage in the narrative. Lightfoot supposes that there may have been a trap-door in the roof of the house, through which the couch was lowered into one of the rooms. Dr. Bloomfield supposes that the actual tiling or roof of the house itself was pulled off piecemeal, and that such a damage could be easily repaired in the slight roof of an eastern house. Dr. Kitto, however, from a closer examination of eastern houses, comes to a conclusion which illustrates very instructively many of the features in oriental house-building. Supposing the house to have a central court, the buildings around it have, on the ground-floor, cellars, offices, store-rooms, and servants' rooms; all the better apartments being above them. All these better apartments open into a gallery, from five to eight feet wide, and fronting the court, having a roof, a floor of squared stones, and a strong wooden balustrade in front. The roof of the gallery is on a level with that of the house itself; but the two are very different in character. The roof of the house has no tiling, no thatch, no lath and plaster; it is usually composed of reeds, branches, and twigs, laid over the rafters, the whole trodden into a somewhat compact mass, and covered externally with earth or plaster, more or less tempered. The roof of the gallery, on the other hand, is far less firm and substantial; it is built of slight materials, and in a slight manner, being intended merely to cover the gallery beneath, whereas the flat terraced roof of the house is made strong enough to walk upon. These points being duly considered, Dr. Kitto supposes that the multitude were in the court-yard of the house, that Jesus was in the gallery, and that the sick man's couch was brought upon the terraced roof of the house itself, and from thence lowered into the gallery through a hole broken—not in the substantial roof of the house, but in the fragile roof of the gallery. This explanation accords with the words of the narrative, and at the same time is in exact conformity with the structure of eastern houses.

The Wood-work and Carpentry of Buildings.

Perhaps the most generally-important of all the matters relating to the construction of dwellings is that which involves the use of wood, since there is no other among the materials capable of being applied in so great a number of ways. In all ages, and in all countries we meet with evidences of the practice of this art. Among the paintings on the ancient buildings of Egypt and Thebes, for instance, we find representations of men cutting wood with adzes and saws (Figs. 683, 684). In modern Egypt too, we have the turbaned sawyers working at the saw-pit (Fig. 685). From an old German wood-cut (Fig. 691) we may gather an idea of the carpenters' tools in use two or three centuries ago; and from the Harleian MSS. we have a group of artisans (Fig. 686) such as were known to our ancestors centuries ago.

In Wilkinson's Manners and Customs of the Ancient Egyptians,' the following occurs as to the doors, carpentry, &c., of the dwellings inhabited by that remarkable people:—"The doors were frequently stained to imitate foreign and rare woods; they were either of one or two valves, turning on pins of metal, and were secured within by a bar or bolts. Some of these bronze pins have been discovered in the tombs of Thebes. They were fastened to the wood with nails of the same metal, whose round head served also as an ornament, and the upper one had a projection at the back, in order to prevent the door striking against the wall. We also find in the stone lintels and floor, behind the thresholds of the tombs and temples, the holes in which they turned, as well as those of the bolts and bars, and the recess for receiving the opened valves (doors). The folding-doors had bolts in the centre, sometimes above as well as below; a bar was placed across from one wall to the other, and in many instances wooden locks secured them by passing over the centre, at the junction of the two folds. It is difficult to say if these last were opened by a key, or merely slided backwards and forwards like a bolt. . . . . . The doors opened inwards, as well those of the rooms as the *janua*, or street-door, contrary to the custom of the Greeks, who were consequently obliged to strike on the inside before they opened it, in order to warn persons passing by to keep at a distance. The Romans resembled the Egyptians in this respect, and they were forbidden to open a street door outwards without a special permission. Sometimes the door of an Egyptian house was in the centre, at others on the side of the court, or of the house itself; but I have found few instances of a flight of steps before the entrance, nor, indeed, is it usual in the houses of modern Egypt; the columns of the porch and corridors were coloured, and, when of wood, they were stained to represent stone; and this fondness for imitating more costly materials, as hard stone and rare woods, proves their love of show, and argues a great advancement in the arts of civilized life. The floors were sometimes of stone, or a composition made of lime and other materials, and the roofs were supported by rafters of the date-tree, arranged close together, or, more generally, at intervals, with transverse layers of palm-branches, or planks."

From some of the engravings given by Wilkinson, there seems reason to think that the fastenings of the doors were often similar to those which Lane represents as being employed in the modern houses of Cairo. In these latter the doors are provided with the very curious wooden lock, sketched in Fig. 693. In No. 1 we have the lock itself with the bolt drawn back; in Nos. 2 and 3 back views of the lock and the bolt; and in No. 4 the key. Four or five small iron pins drop into corresponding holes in the sliding bolt, as soon as the latter is pushed into the hole or staple of the door-post; the key also has small pins, made to correspond with the holes into which they are introduced to open the lock: the former pins being thus pushed up, the bolt may be drawn back. The sliding-bolt of a street-door lock is usually rather more than a foot long; those of apartments and cupboards, seven or eight inches; and those of gates and public buildings, two feet or upwards.

Other evidences of ancient art in these departments are met with at Pompeii, where such door handles, bolts, keys, and hinges have been found as those sketched in Figs. 687, 688, and where tools such as those in Fig. 692 have been also found.

It is scarcely necessary to attempt any description of the mode in which the carpenter, by the aid of the saw, the plane, and a few other tools, works up timber into the various forms which are so familiar to us in the construction of a house. A very few details will be all that need here be given.

In the first place the timber, as imported from Canada or Norway, or as cut down in our own country, is sawed into planks and other forms by means of large vertical saws, worked by two men, of whom one stands beneath in a pit to guide the lower end of the saw, while another stands above to guide the upper end. The subsequent sawing into smaller pieces is effected by hand-saws, each of which can be worked by one man. The pieces thus produced may or not be brought to a state of smoothness by the plane, according to the purpose to which they are to be applied. The ends of such pieces often require very ingenious modes of adjustment, in order that one may be connected with another, to form the numerous kinds of frame-work exhibited in the skeleton and fittings of a house. Thus, when one beam is to be attached to or supported by another, without resting on it, but so that both beams may be in the same plane, the "tenon and mortise" joint is often adopted; the "tenon" is a reduced portion of the end of one beam, while the "mortise" is a hole of corresponding size in the other beam. When two beams are to be so joined together as to be enabled to resist any strain apt to separate them, a "dovetail" joint is used; this is produced by cutting the end of one beam to the shape of an inverted wedge, and making a suitable hole to receive it in the other. When two beams of equal in thickness are required to cross each other, and to lie in the same place, they are often "halved" together; that is, a notch is cut in each beam, equal in depth to half the thickness of the other beam, and the uncut portion of each lies in the notch of the other. There are other modes of joining timbers together, but these are the principal.

It often happens, however, that a beam of wood is either not long enough or not strong enough for the purpose to which it is to be applied; and to remedy these deficiencies, it is *scarfed* in the one case, and *trussed* in the other. Two beams of timber laid end to end, to produce one of greater length, could obviously not be united strongly without some kind of overlapping or intersection; and the mode in which this intersection is produced is called "scarfing." Figs. 669, 670, 671, 672, 673, 674, represent six different modes of effecting this, all differing somewhat in details, but all produced by cutting away a portion of each beam to receive a portion of the other. The joined ends are secured together by bolts or spikes, and sometimes by other pieces of wood placed outside them. In *trussing* a piece of timber as a means of increasing its strength, bars or rods, either of wood or of iron, are fastened to the main beam in a number of different ways, of which two are sketched in Figs. 678, 679.

The roof of a house is, perhaps, among the most curious specimens of the art of carpentry, arising from the many different modes in which strength of arrangement is attained. In the first place the shape of a roof is one of the points which determine the structure. Figs. 695 to 699 represent five forms of roof, as seen from above, from the side, and from the end. Five other cuts (Figs. 675, 680, 681, 682, 694) represent different combinations of pieces of timber to form the skeleton frame-work of roofs. These pieces have various and often rather odd names, such as "wall-plates," "ridge-pieces," "rafters," "hip-rafters," "gutters," "jack-rafters," "purlins," "principals," "tie-beams," "trusses," "pole-plates," "king-posts," "struts," "queen-posts," "collar-beams," "straining-sills," "cumber-beams," and many others; some of which are horizontal, some vertical, and some inclined, and all being connected by such joints as were before alluded to.

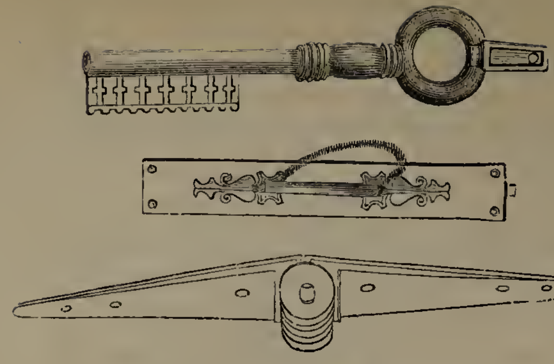
Many parts of fine carpentry, or, as it is then called, "joinery," depend on the use of planes, by which an ornamental contour is given to a moulding or piece of wood; and this, with the more delicate modes of joining pieces of wood together, render this a higher branch of mechanical art than carpentry as such.

Shops and Bazaars, as examples of Building.

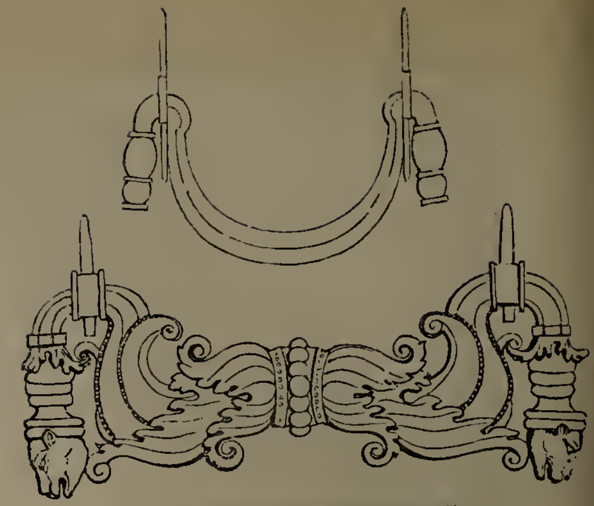
We have glanced rapidly at the chief industrial arts involved directly in constructing the shell of a house; but before proceeding to notice the more decorative departments, we may say a word or two respecting those structures which are designed rather as places of business than as dwellings, such as shops and bazaars.

The bazaars of an oriental city, such as that sketched in Fig. 676, consists usually of a connected series of avenues or arcades, which are sometimes vaulted with high brick roofs, while in others (as in the cut) they have flat timber roofs supported by vertical timbers. The approaches to the bazaars are commonly lined with low shops, in which commodities of little value are exposed for sale. These approaches are sometimes open to the sky, but are more generally covered in a rude manner with branches of trees, and leaves laid upon beams. "In the best specimens of the vaulted bazaar,"

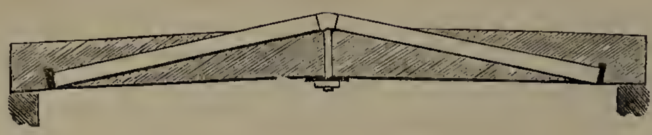
683.—Cutting Wood with Adzes. (From an ancient Egyptian Painting.)



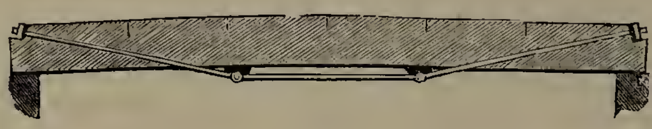
687.—Bolt, Key, and Hinge, from Pompeii.



688.—Door-handles, from Pompeii.

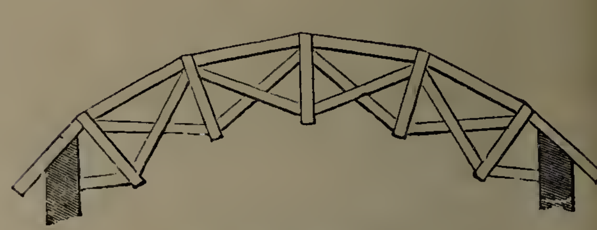


678.



679.

678 and 679.—Modes of strengthening Timber.

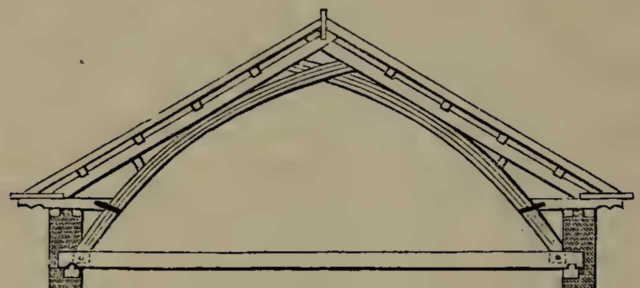


680.—Carpentry of Roof.

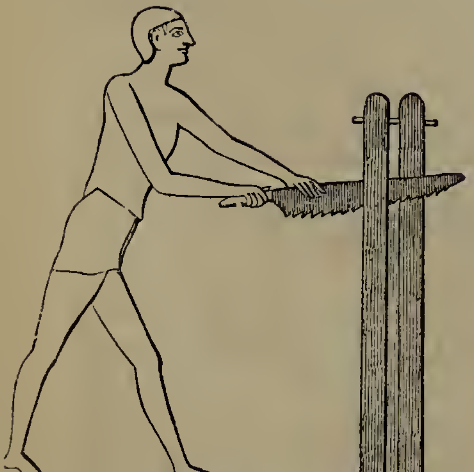
689.—Pantheon Bazaar.

686.—Group of Artisans. (From Harl. MSS.)

681.—Carpentry of Roof.



682.—Carpentry of Roof.



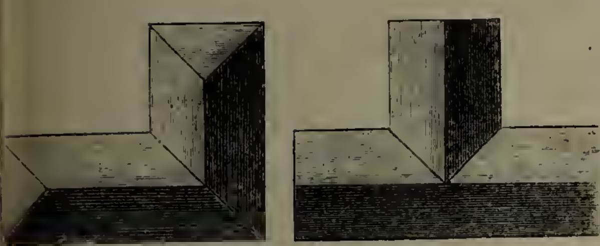
684.—Sawing Wood. (From an ancient Egyptian Painting.)

690.—Posts at Door-step.

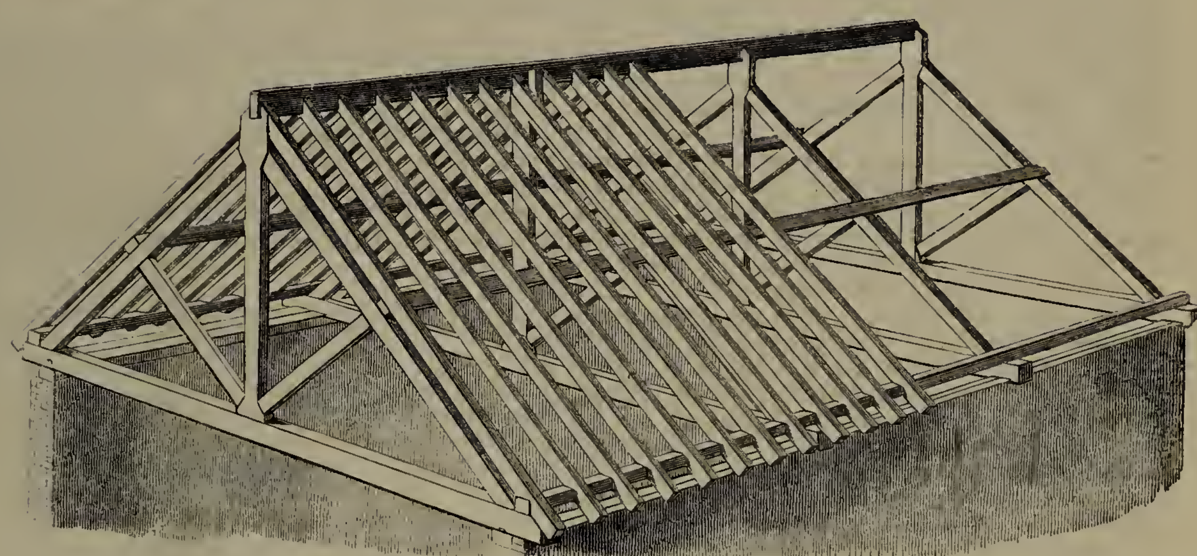
685.—Egyptian Sawyers.

703.—Shop-front in Regent Street.

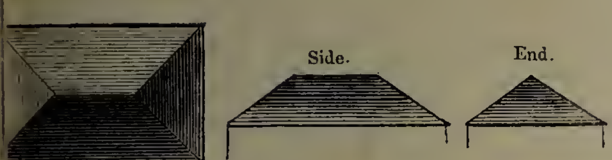
691.—Carpenters and their Tools. (From an old German Woodcut.)



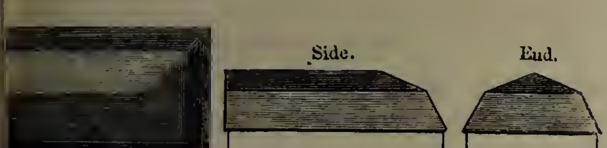
695.—Roof.



694.—Carpentry of Roof.

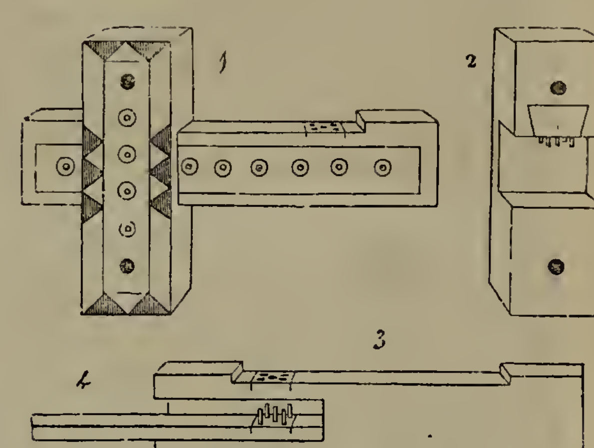


696.—Roof.

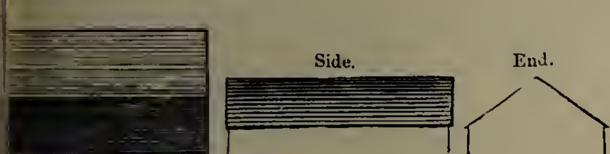


697.—Roof.

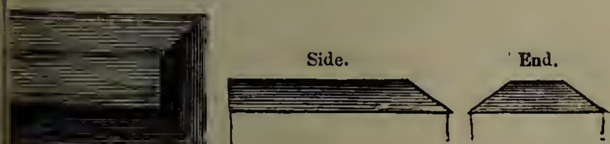
702.—Cobbler's Stall, about 1760.



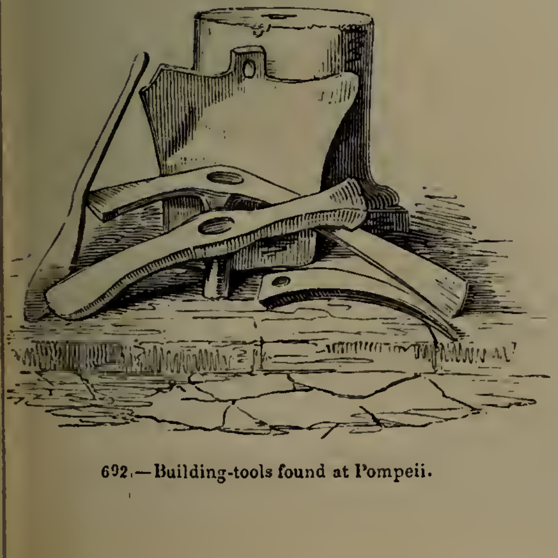
693.—Wooden Lock, as used at Cairo.



698.—Roof.



699.—Roof.



692.—Building-tools found at Pompeii.

701.—A "Frippery," or Clothes stall in Shakspere's time.

700.—Supposed form of a Shop, Pompeii.

it has been observed, "the passages are lined on each side with a uniform series of shops, the floor of which is a platform laid from two to three feet above the level of the ground, and faced with brick. As the vault springs from the front of the line of shops, they seem like a series of recesses, and the partition-walls between them appear like piers supporting the arch. These recesses are entirely open in front, in all their height and breadth; they are scarcely more than very small closets, seldom exceeding six feet in breadth, rarely so deep as wide, but generally from eight to ten feet in height, and occasionally more. But in the more respectable parts of large bazaars, there is generally a little door in the back wall which conducts to another small and dark closet, which serves the purpose of a store-room. The front cell is the shop, on the floor of which the master sits with his goods all around him, the articles most in demand being placed so within his reach that he has seldom occasion to rise."

In many of the oriental cities, nearly the whole of the retail shops are to be met with in the bazaars, each department having a bazaar of its own. Thus there are bazaars for smiths, braziers, shoemakers, saddlers, potters, cloth and chintz sellers, tailors, and other handicraftsmen; as also others kept by confectioners, cooks, apothecaries, bakers, fruiterers, greengrocers, &c. Sir Robert Ker Porter thus speaks of a bazaar at Bagdad:—"In proceeding to Mr. Rich's house, the point whither we were moving, we crossed through part of the great bazaar. It was crowded with people, and displayed every kind of Asiatic commodity for traffic. Numberless coffee-houses, intermingled with shops, were ranged on each side, all of which were well stored with silent and smoking guests seated in rows, like so many painted automatons. There was a rustling sound of slippered feet and silken garments, and a low monotonous hum from so numerous a hive; but nothing like the brisk abrupt movement and clamorous noises of a Persian assemblage of the same sort."

It is curious to look back through a period of nearly two thousand years, and fancy ourselves in a retail shop among a people whom we are accustomed in general only to think of in connexion with high-sounding deeds of prowess. The Roman shops of Pompeii are believed to have borne no inconsiderable a resemblance to some among the open shops of the present day. There is among the ruined houses in one of the streets a building which is believed to have been a sort of cook's shop, a place for the sale of dressed provisions, and from various collateral circumstances it is supposed to have presented, when in a perfect form, some such appearance as that shown in Fig. 700, the wall around the shop being painted with emblems of the kind of traffic carried on within.

In Cairo, and many other oriental cities, the shops, when there are any such existing independent of the bazaars, are generally open in front, and the shopkeeper places himself much in the same situation and attitude as he would in a bazaar (Fig. 677). The streets in such towns are often so narrow, that it is a matter of some difficulty for passengers to work their way along.

In our own country the shops have undergone a good deal of change, a far more costly and elegant style of construction being now adopted than was known at any former period. In olden London it was customary to have the shops open in front. Even so late as the time of Queen Elizabeth, and probably much later, the shops frequently presented the appearance shown in Fig. 701, which was a "frippery," or clothes-shop of Shakspere's time. If we bear in mind that there are still "cobbler's stalls" in the metropolis, such as that shown in Fig. 702, it may help us to form some conception of the little odd-shaped shops of former times; for though we must not say that such diminutive and cramped proportions were observed in shops generally, yet the majority of the shops represented in old prints bear much more resemblance to a cobbler's stall than the splendid shops of our own day.

Let us take Fig. 703 as a representative of this new and magnificent style. Those persons, whether Londoners or visitors to London, who are acquainted with the vicinity of the Quadrant, in Regent Street, will probably recognise this shop as occupying the southern extremity of the Quadrant. The combination of decorative ornament and of gigantic panes of glass, gives it an appearance truly remarkable. Of this shop it was said, in the 'Companion to the Almanac' for 1841:—"As an architectural composition it possesses considerable merit, presenting the appearance of sufficient solidity and strength, and not looking as if likely to be crushed by the upper part of the house; for, though spacious, the windows are of lofty upright proportions and arched, besides which there is some substance in the piers to which the columns supporting those arches are attached, and where the angle of the building is curved off, that space presents a broad solid pier; not, however, one that produces a blank in the composition, it being sufficiently enriched with panelling." There are many other shops in the metropolis, both in the city and at the west end, which exhibit great sumptuousness in the arrangement and fittings; and it is observable that plate glass forms one of the most decided features in the decoration. This is selected because, from the great beauty, clearness, and freedom from all irregularities of substance or surface, it affords a much better medium than any other kind of glass for exposing to view the fancifully-arranged goods within the shop-window. A recent architectural critic has remarked, in connexion with this subject, that "Glass, in street architecture, is only just beginning to excite attention. The shopkeeper is more interested in calling the attention of the passengers to his wares than in obtaining light from the front windows for his counter. To him, consequently, the recent facilities afforded for obtaining plate-glass have been a decided boon; and he has, in fact, been enabled to exhibit his goods as if no *media* intervened between them and the spectator. To this illusion the glass used in shop-fronts should bear constant reference; and this was tried, with nearly complete success, in Regent Street, where a single plate of glass, between two palm-trees, gave the effect of an alcove, where upholstery was arranged to rest and gratify the luxurious traveller. The design, however, was sadly marred in the execution; but this is not the only instance in which the constructors of shop-fronts have perversely sought to force the existence of the expensive glass upon notice, forgetting that the suggestive purpose of a large plate of glass is to destroy the notion of intervention, and identify the window with the atmosphere.

The Pantheon Bazaar (Fig. 689) is one of those buildings which form a connecting link between the bazaar system of the East and the shops of Europe. Originally this was a theatre; and therefore, as a specimen of architecture or of building, it has no particular relation to other places for retail traffic. But at the same time it affords a favourable opportunity of showing what may be done when taste is brought to bear upon that which constitutes in itself nothing more than shop-keeping.

THE INTERNAL DECORATIONS OF BUILDINGS.

A bird's-eye view has thus been taken of the most prominent among those industrial arts which relate to the construction of buildings; leaving wholly untouched, as belonging to those higher departments of art not entered upon in this volume, the relation which such buildings bear to any particular style of architecture. It may now be interesting to visit the interior of our imaginary dwelling, and trace the operation of those arts (or the more conspicuous among them) whereby the rough walls and timbers and floors lose their crude appearance, and become fitted for the houses of civilized and cultivated nations. The glass for the windows will form an appropriate commencement of this part of our subject; and as the various kinds of glass are sufficiently alike in composition and manufacture to be described together, we will notice them in this place.

Glass-making: Flint-Glass.

It would be difficult, perhaps, to point out a more beautiful product of industrial art than glass. Its brilliancy, clearness, hardness, smoothness, transparency,—all tend to make it a general favourite among all nations able to obtain it. As window-glass, as plate-glass, as flint-glass, as bottle-glass, it presents many varieties of appearance, but is valuable in all.

Let us first see how the arrangements for making the glass are conducted, before noticing the combinations of ingredients. Glass-furnaces, or "glass-houses," are differently formed according to the kind of glass made. In the flint-glass works there is usually a large building, square and lofty, having an earthen floor, and a furnace in its centre, the chimney from which rises up through the roof of the building. If the furnace were cut vertically down through the middle, it would present some such an appearance as Fig. 704. There are two hemispheres, one within the other, the innermost of which is filled with fire and flame, and the space between the two is occupied by the smoke before it ascends the chimney. At *b* are the flues by which the whole is heated, and at *a* are the large earthen or clay pots in which the materials for the glass are melted. Transferring our attention next to Fig. 705, we see the appearance which would be presented if the floor of this furnace could be viewed from above. At *a* are the flues for heating the furnace; at *b* the ground on which the pots are placed; at *c*, the pots themselves; and at *d*, a central grate for admitting draught to the fire. The whole of the arrangements are so managed as to lead to the production of a very intense heat within the furnace. In Fig. 706 we have the circular furnace, shown in relation to the other parts of the glass-house; and we can here see certain openings by which the workmen obtain access to the melted glass within.

The melting-pots are curiously formed (Fig. 707). They are formed of Stourbridge clay, mixed up with the materials of old pots ground to powder, and the composition worked up and kneaded with water until it forms a very fine and smooth clay. This clay is divided into small pieces, and is built up into the form of a pot much in the same way as a boy would build a grotto with oyster-shells, each piece being well-pressed down before another is applied. The quantity of material employed is very large, for the pot is about a yard in height, nearly a yard in diameter, and varying from two to three inches in thickness. It has only one opening; and this, which is rather curiously shaped, is so placed that no flame or smoke can get into the inside while the pot is in the furnace; while at the same time the workmen can have access to the melted contents from without. When the pots are made, they are allowed to remain several months to dry gradually in a cool room; they are next kept for a shorter period in a warmer room; and are afterwards exposed for four or five days to the intense heat of an oven or furnace. While yet red-hot, or rather white-hot, from this firing, they are drawn out of the oven, and transferred to the melting-furnace, which is opened for their reception. So much of the success of the manufacture depends on the soundness and proper condition of the melting-pots, that a large share of the manufacturer's attention is devoted to this matter.

Then comes the consideration of the kind of ingredients placed in these melting-pots, as a material for glass; a subject full of surprising results. Who would suppose, from a mere consideration of the materials individually, that so beautifully transparent a substance as glass should result from the mixture of grains of sand with soda or potash, with or without red-lead? One of these is as hard and opaque as stone generally, another is a red paint not less opaque, while the third—soda or potash—though not quite so opaque as the others, is very far indeed from resembling glass either in transparency or hardness or smoothness. Yet from such ingredients is glass made; any modification, to suit any particular kind of glass, being wholly of a subordinate character.

The origin of glass, like the origin of many other useful substances, has been made the subject for several curious surmises. According to one of the current legends, the invention of glass thus arose:—There was on one occasion a merchant vessel, laden with nitre (one form of the alkali potash), driven ashore on the coast of Palestine, near the mouth of the river Belus, a small stream running from the foot of Mount Carmel into the Mediterranean. The mariners, unable to procure stones to rest their cooking-vessels upon, used pieces of the nitre instead. The fire reduced the alkali to a soft state, and enabled it to incorporate with the river sand, forming together a stream of liquid glass. The circumstance was communicated to the inhabitants of the district, who availed themselves of the hint, and established a manufacture of glass. Whether or not this version of the story be taken as the true one, it is certain that the art of making glass was known to the Phœnicians and the Egyptians long before Europe had emerged from barbarism. Wilkinson adduces proof that the Egyptians practised the art more than three thousand five hundred years ago. At Thebes there are paintings representing glass-blowers at work; and from the hieroglyphics accompanying them, it is found that they were executed in the reign of a monarch who occupied the throne before the exodus of the children of Israel from Egypt.

But to return. The ingredients for glass, we have said, are chiefly sand, alkali, and red-lead, or oxide of lead. The sand employed for this purpose is river-sand, brought chiefly from the shores of Lynn, in Norfolk. Formerly flints used to be employed, ground to a very fine state, and hence the name of "flint-glass;" but sand has now wholly superseded flint for this purpose. The alkali employed is chiefly the carbonate and the nitrate of potash. The sand is first well washed, to free it from all adhering impurities, and is then dried in or over an oven. The alkali is also washed and evaporated, to bring it to a clean state: and the two, when properly prepared, are mixed together, and to them is added a portion of oxide of lead. The relative quantities for flint-glass are about one part of alkali, and two of oxide of lead, to three of sand, with a very minute quantity of one or two other ingredients; the whole forming a kind of salmon-coloured powder. As the ingredients take a considerable time in melting, the arrangements of a flint-glass house are generally so conducted as to make one routine of operations, or the consumption of one supply of material, occupy a week. In the first place, the materials are placed in the fiercely-heated melting-pots on Friday morning, through the openings in the furnace; the quantity put in is about four cwt.; and when this has been introduced, the opening or door is bricked up, and the fire strongly urged; when this quantity has sunk and partly melted, another similar quantity is introduced, and so on three or four times, until at length each pot contains fourteen cwt. of materials. This is allowed to remain exposed to heat throughout Friday, Saturday, and Sunday; and on Monday morning, the mixture having arrived at the state of a molten golden lava, the workmen commence operations. The mouths of the furnace are opened, so as to give access to the melted glass; and the men assemble in front of these openings to prosecute their very remarkable labours.

Let us suppose that a glass jug, or decanter, or vase is to be made. A man takes a hollow iron tube, six or seven feet long, and, putting one end of it through an

opening in the furnace, dips it into a pot of melted glass, and takes up a small quantity at the extremity. The glass so collected appears like a projecting lump of red-hot iron, having a dough-like consistency. The workman whirls the rod two or three times round his head, to elongate the mass of glass, and then rolls it on a flat iron plate to give it a regular shape (Fig. 708). He then holds up the tube horizontally (Fig. 714), and blows through it, by which the mass of glass at the other end is made hollow within. This alternation of rolling and blowing is repeated two or three times, after which the tube is taken by another workman, who is seated on a stool having two long projecting arms (Fig. 709). He rests the tube on these arms, and rolls it backwards and forwards to prevent the glass from falling off the end. A boy, stooping down, blows through the tube, whereby the glass is made more and more hollow; and while this is going on, the man proceeds to shape the glass in a very remarkable manner. With an instrument shaped something like sugar-tongs, he compresses the glass at one part, expands it on another, gives it graceful curves, bends one portion to form a lip or spout or edge, and gradually brings about a definite shape to the article. While effecting this, the glass speedily becomes too cold to have the requisite plastic quality; and he therefore from time to time rises from his seat and holds the glass (still adhering to one end of the iron tube) to a highly-heated opening in the furnace (Fig. 715), by which it is brought to the proper degree of heat and softness. Thus the heating, the blowing, the rolling, and the modelling proceed, until at length the article assumes somewhat the form of the intended vessel. If the vessel is to have a foot, another workman brings a little melted glass on the end of a rod, and applies it to the bottom of the former piece, where the first workman speedily fashions it into a foot or stand. If the vessel is to have a large wide lip, a portion of the edge of the glass is cut away with a pair of scissors, and the remainder quickly shaped by the modelling tools. If it is to have a handle, an assistant workman brings a little glass on the end of a rod, and this is attached to the vessel and brought to the proper form in an inconceivably short space of time. Indeed, the whole train of processes is exceedingly remarkable; the power of the workman over his material is such that he can with the slightest touches mould and bend the form to his wishes. The possibility of effecting this depends upon the proper state of the glass; and the workman knows instantly when his material requires reheating at the furnace-mouth.

In larger articles, such as lamp-shades, salvers, goldfish vases, &c., the mode of managing the glass is not less remarkable than in making vessels with handles and feet. In such cases the workman collects a sufficient quantity of glass on the end of a tube, and blows through the tube until the mass of glass becomes hollowed out into the form of a sphere; another man then takes up a little melted glass on the end of an iron rod, called a "punty," and applies it to the opposite side of the hollow glass: the glass instantly adheres to it; and by a dexterous manœuvre the tube is detached. The glass (now attached to the rod instead of the tube) is reheated and whirled round and round, until it loses its globular form, and expands into an oval or a flattish form, according to the kind of article which it is intended to produce: the place where the tube had been detached forms a hole, which expands more or less according to circumstances.

In making glass tubing, such as that employed for thermometers and barometers, the ductile nature of red-hot glass is illustrated in a most singular manner. A sufficient quantity of glass is taken up on the end of a tube, and is made hollow within by blowing; it is then pressed or beaten gently, in order to give to the hollow space within any desired shape, whether cylindrical, as for tubing generally, or flattened, as for the bore of thermometers. The workman holds out this mass of glass horizontally; and another workman applies a heated rod to the other end of the glass. The two men then walk backwards, receding from each other; and the glass elongates as they proceed; until at length that which was before a mass of glass only a few inches long, becomes a thin and delicate tube forty or fifty feet in length. This tube hangs down as it is formed, and lies along a ladder placed on the floor of the glass-house. When set a little, the long tube is lifted up, and a man applies a piece of cold iron, by which it is broken into pieces of convenient length (as shown in the left hand of Fig. 706). The most remarkable feature in this process is, that whatever form be given to the internal cavity of the mass of glass, the same form is retained throughout the subsequent elongation, however much the diminution of size may be.

The various articles of flint-glass, being formed by the processes of blowing, rolling, and modelling above described, are then annealed, to lessen the brittleness which they would otherwise have; this annealing consists in a very slow cooling, so that the internal substance and the outer surface of the glass may cool and contract as equably as possible. Each vessel or other article, as made, is taken up on the end of a kind of pronged or cleft fork, and placed on an iron pan called a "leer-pan." This pan, when filled, is placed in the annealing oven called the "leer," where it is exposed to a gradually decreasing heat. A period of from twelve to sixty hours is allowed for the cooling, according to the thickness of the glass. When cold, they are removed from the oven.

Many articles of flint glass are deemed finished at this stage of the manufacture; but those which are "cut" require a yet further process. This term, "cut," as applied to flint-glass, is not quite correct: when a sheet of window-glass is divided into square panes by means of the glazier's diamond (Fig. 710), it is properly termed "glass-cutting," because the edge of the diamond acts on the glass as the edge of a knife would on a softer substance; but the cutting of flint-glass is really *grinding*. In effecting this grinding, each workman has before him a thin wheel revolving on a horizontal axis; and above is a vessel containing water (and sometimes sand), which trickles down on the wheel. There are means for adjusting the wheel, and replacing it with others of a different kind: some of the wheels employed are of cast-iron, some of wrought-iron, some of Yorkshire stone, and some of willow wood, according to the kind of work to be done; the edge of each wheel is the part which effects the grinding process, and these edges have various forms to suit different purposes. The workman takes the glass vessel or other article in his hand, and applies it to the edge of the rapidly revolving wheel (Fig. 711); according to the pattern which he desires to produce, so does he employ wheels of varying shapes, and holds the vessel in various positions, till the cut or rather ground portions present the ornamental appearance which is the object of his labours. He uses the iron wheels, wetted with sand and water, to grind away the substance of the glass; stone wheels, wetted with clean water, to smooth the surface; and wooden wheels, with tripoli or putty-powder applied to their edges, to give the final and brilliant polish. According to the form and purpose of the glass vessel, and the taste of the workman, so are the ornamental details worked out, whether a tall jug, like Fig. 712, or one of flatter form.

Another mode of decorating flint-glass is by engraving fine devices on its surface,—not with the aid of a graver, but with the edges of wheels analogous in principle to those used in grinding. Though similar in principle, however, the two processes differ much in details. The tiny grinding-wheels employed by the engraver are in some cases not above an eighth of an inch in diameter, varying from that up to two inches: they are fixed on a horizontal axis, and are moistened at the edges with a little emery and oil. The engraver, who must be a man of taste as well as a skilful workman, forms a pattern, and holds the vessel to the edges of the little wheels (Fig. 713) in such a manner as to grind away a small portion of the substance of the glass along the whole of the lines of the device. This engraving is left dead, or semi-transparent and unpolished, and has a beautiful effect when relieved by the transparency of the other parts of the glass.

Before quitting the subject of flint-glass, we will quote from the 'Art-Union' the following remarks on the customary forms given to articles of this material:—"Bottles, decanters, and drinking-glasses are such matters of universal use, that we sometimes have been surprised at the little variation of form and decoration to be found in them. The form of bottles appears to have been determined by prescription, and to have been fixed in that which renders them unfit for mess-tables; but assuredly there can be no reason assigned for perpetuating ugliness to any article, or taking for a model a gas-pipe stuck into a beer-barrel. The neck of the bottle must be a cylinder of narrow diameter, and the body a cylinder of large diameter; now the cone furnishes a beautiful means of making an easy transmission from one to the other, and we can see no reason why our old friend Port should be worse treated than our modern acquaintance Hock. Most cut decanters are spoiled by what was designed for decoration; Art can recognise nothing as an ornament which has not some immediate or remote significance. We can understand the propriety of the grape-cluster or the vine leaf; but, unless we are expected to make libations to the host of heaven and revive the Chaldean idolatry, we are utterly unable to discover a reason for carving decanters with suns, moons, and stars. . . . . Wine-glasses have always appeared to us objects for the display of much artistic skill and ingenuity. They have a model in nature, the flowers of the field holding in their cups the dew of heaven; but to these models we rarely find their makers pay the least attention. The tulip-glass, as it is called, was undoubtedly borrowed from the flower whose name it bears; but the modeller unfortunately took it into his head to improve nature, and has wandered wide from his pattern. In the best specimen of these glasses which we have seen, the whole effect is marred by omitting the tulip-stem. A crocus is a beautiful model for the short-stemmed glasses of modern days, and we wonder that it has so long escaped notice. . . . . We cannot avoid expressing some regret for the disappearance of the long-stemmed Dutch glasses so often represented in the pictures of Teniers. Nature has given us, in the tribe of flowers, beautiful models of stem as well as of cup. It must, however, be remembered that, in Nature's perfect harmony of proportions, each flower has its own appropriate stem; and the modeller must therefore take care not to combine the stem of one plant with the cup of another."

Glass-making: Window Glass.

The glass for windows is generally called *crown*-glass, and is made in circular sheets three or four feet in diameter. If these sheets could be made square instead of circular, a great saving of material and of time would be effected in cutting them up into panes for windows; but the peculiar manner in which they are made renders a circular form unavoidable.

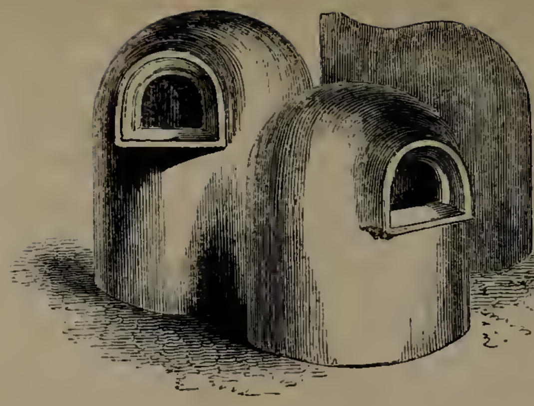
The furnace arrangements for crown-glass differ in some points from those for flint-glass. There is a furnace in the centre of the building in both cases; but the space around this furnace is not similarly occupied in the two cases. There is a passage left open around the crown-glass furnace; and on the other side of the passage are the openings of a number of ovens or other furnaces, wholly distinct from the central furnace. The glowing glass is taken out of the pots within the central furnace, as in the former case; but the working operations are conducted at or near the other furnace-openings.

The materials for crown-glass do not differ very materially from those for flint-glass, except in the important point of containing no oxide of lead. This oxide is employed in flint-glass, because it gives the glass greater density, greater power of refracting light, greater lustre, greater resistance to fracture from sudden heat and cold, and greater facility during the working; qualities which are more called for in flint-glass than in crown. The sand employed is the same, brought from Lynn, or from Alum Bay in the Isle of Wight. The alkali differs in quality and kind according to circumstances. A curious change has taken place in the mode of obtaining a supply of alkali. In former times, glass-makers used to employ large quantities of *kelp*: this was an impure carbonate of soda, which gave off its carbonic acid and its impurities by the action of heat, and entered into the composition of glass in the state of soda. About a century ago the manufacture of this alkali was commenced on the shores of the northern and western islands of Scotland, where the sea-weed which constitutes kelp was found in great abundance. Dr. Macculloch gives the following account of the kelp-making operations:—"The kelp season had now commenced, and the whole shore was one continued line of fires; the grey smoke streaming away from each on the surface of the water, till, mixing with the breeze, it diffused its odoriferous haze over all the surrounding atmosphere. . . . . The weeds, being cut by the sickle at low water, are brought on shore by a very simple and ingenious process. A rope of heath or birch is laid beyond them, and the ends being carried up beyond the high-water mark, the whole floats as the tide rises, and thus, by shortening the ropes, is compelled to settle above the wash of the sea, whence it is conveyed to dry land on horseback. The more quickly it is dried, the better the produce; and when dry it is burned in coffers, generally constructed with stone, sometimes merely excavated in the earth. In Orkney the latter are preferred. As twenty-four tons of weed at a medium are required to form a ton of kelp, it is easy to conceive the labour employed for this quantity in the several processes of cutting, landing, carrying, drying, stacking, and burning." Since Dr. Macculloch wrote, however, a great change has come over this department of industry. When the chemical mode became developed of obtaining soda from common salt, and at a price so small as to completely undersell kelp in the market, the demand for the latter material gradually lessened, and the Highlanders ultimately lost completely a source of income which had been to them by no means inconsiderable.

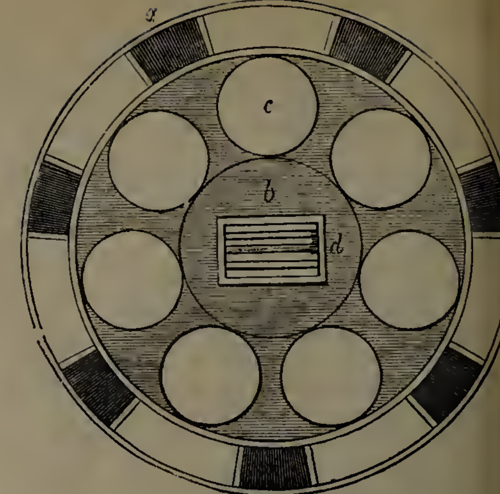
The sand and the alkali, and the few other ingredients necessary for crown-glass, before being actually mixed in the melting-pots, undergo a process called *fritting*; the object of which is to bring them into a more homogeneous state. The materials being mixed together, the mixture is placed in a shallow calcining-oven, where it is exposed to a degree of heat sufficient to bring it to a liquid state; it is kept stirred for some time while in this state, and gives off carbonic acid, and suffers in other respects changes which enable the alkali to combine more intimately with the sand. When finished, the mixture or "frit" is taken from the oven, and spread out in a thin layer upon a large flat plate: it is divided into small cakes before quite cold, and these cakes are kept some considerable time before being employed to make glass.

When matters are ready to commence the manufacture, the frit is thrown into the white-hot melting-pots in the furnace, and there melted together with some "cullet," or broken glass. Impurities rise to the surface, and are skimmed off; and when the glass is completely melted, it is allowed to cool in a very slight degree, as it is in a better working state when a slight degree of viscidity or thickness has commenced. Several men join in the labour of making one circular sheet of glass. One, called the "gatherer," approaches

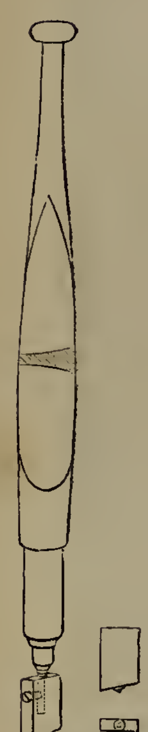
704.—Section of G'ass-furnace.



707.—Pots for melting Glass.



705.—Ground-plan of a Glass-furnace.



710.—Diamond for cutting Glass.

706.—Flint-Glass Furnace.

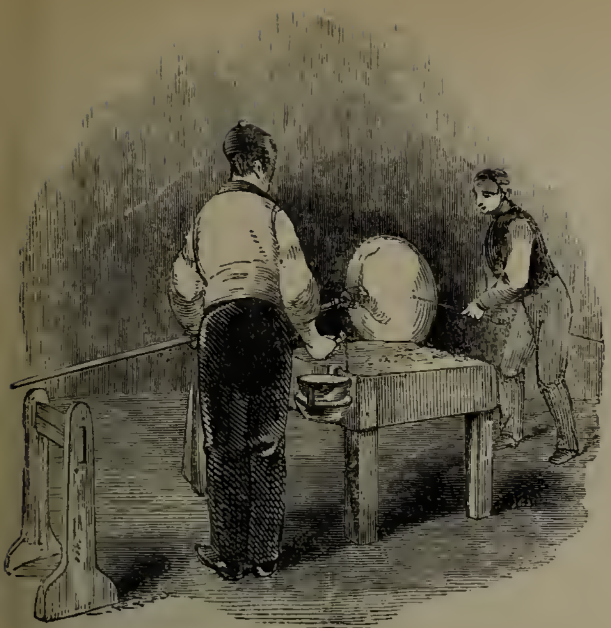
712.—Specimen of cut Glass.

708.—Preparing for Glass-blowing.

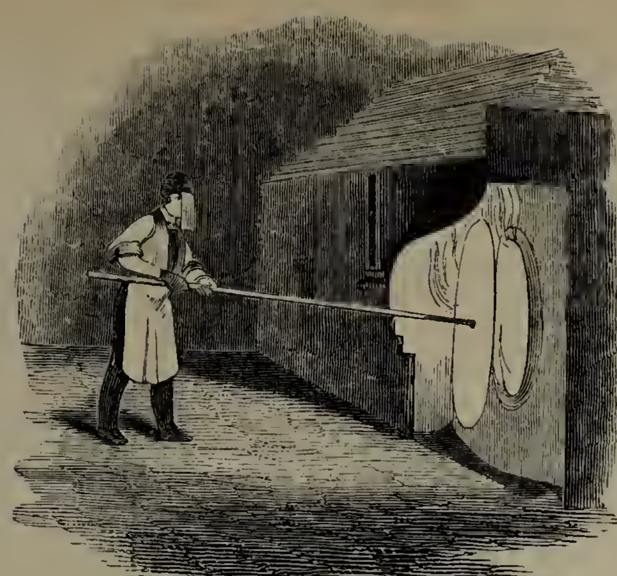
713.—Glass engraving.

711.—Glass cutting.

709.—Shaping a Flint-Glass Vessel.



716.—Transferring from the Tube to the Pontil.



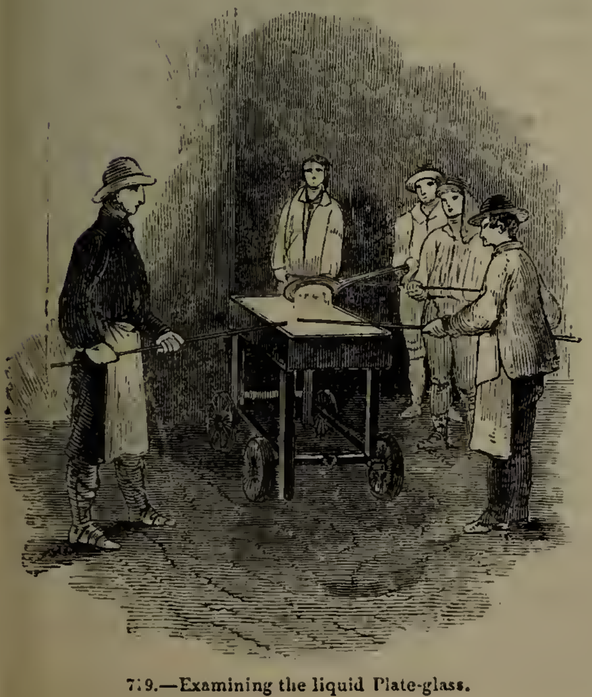
717.—"Flashing-out" Crown-glass.

722.—Glass-bottle making.

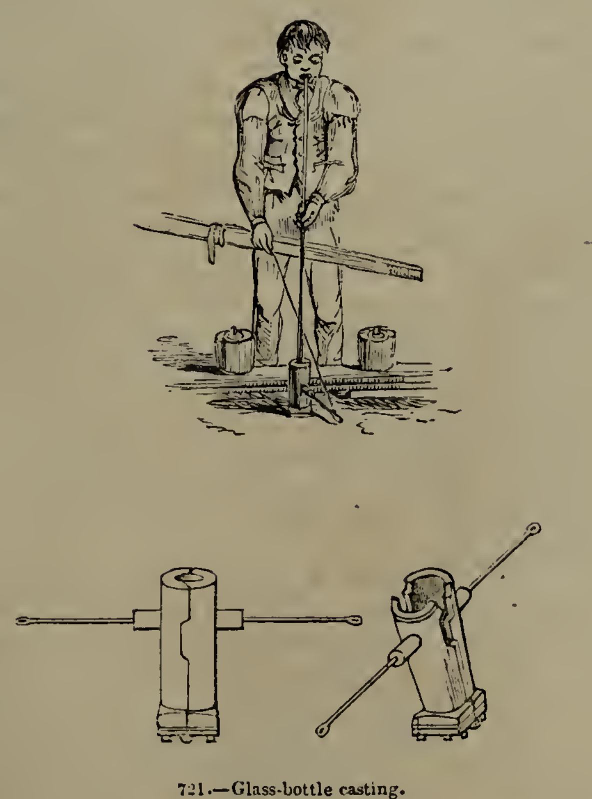
720.—Plate-glass-casting.

714.—Glass-blowing.

715.—Glass-blowing.



719.—Examining the liquid Plate-glass.



721.—Glass-bottle casting.

718.—Sheet-glass making.

one of the furnace-mouths, and dips the end of a rod into the melted glass; allows this to cool a little; dips again; allows this additional quantity to set; and so on until he has collected about nine or ten pounds of the glowing and pasty glass on the end of the tube. He holds the tube vertically, to let the glass stretch out a little beyond the end of the tube; then rolls it on a flat marble slab; and then blows through the tube to make the mass of glass hollow within. The tube is next handed to another workman called the "blower," who heats the glass at the furnace-mouth two or three times, and after each heating blows and rotates it. By this series of processes the mass of glass becomes nearly a globe in shape; and it is then transferred from the tube to an iron rod (Fig. 716) by another man, in the same way as with flint-glass. The globe is then "flashed out" into the form of a flat circular sheet by a process equally beautiful and surprising. The workman stands before a fiercely heated furnace-mouth (his face shielded by a handkerchief), and holds the rod horizontally, so that the glass globe may be exposed to the heat: he keeps the rod revolving unceasingly, and by degrees the glass becomes so soft and yielding that it loses its globular form, gets flatter and flatter, and at length bursts out suddenly into a circular sheet (Fig. 717). While yet hot, but just solid enough to hold together, the workman carries it a short distance, and lays it down flat on a bed of sand; another workman touches it at the junction of the rod with a piece of cold wet iron, which separates the rod; a third man lifts up the circular sheet on a two-pronged fork, and places it in an annealing-oven.

When the pieces thus made are to be used for glazing or other purposes, they are cut up into square panes by means of the diamond. The small mechanism seen in Fig. 710 shows the several parts in the modern or "patent" diamond, adapted to the crystalline structure of the gem. At *c* there is the extreme end of the diamond, with the gem in its centre; at *b* is a side-view of a small brass box or case into which the gem is fixed; at *h* is a kind of pivot, which allows a handle to be fitted to the diamond; and at *a* is a screw for adjusting and fixing the handle.

Glass-making: Plate-Glass.

This kind of glass is perhaps more free from specks or blemishes than any other; the test to which it is often exposed—that of having a brilliantly reflecting surface of mercury behind it—is so severe, that nothing but very careful manufacture could stand it.

The Venetians were the first to bring this manufacture to any distinction, whether or not (which is rather improbable than otherwise) they were the original inventors of it. At one period, so useful and honourable were deemed the labours of the glass-makers at Venice, and so large was the revenue which the manufacture brought to the state, that the senate made free burghers of all the glass-makers, and allowed nobles to intermarry with their daughters, a condescension not otherwise permitted in that aristocratic city. In France, at a somewhat later period, the same principle of encouragement was carried to a still greater extent; for it was decreed, not only that no degradation should follow from the practice of this art among the nobility, but even that none excepting gentlemen, or the sons of noblemen, should engage in any of its branches. In 1673 plate-glass was first made at Lambeth, in works supported by the Duke of Buckingham, but soon abandoned. Exactly a century after that period an establishment was founded on a scale of considerable magnitude for the manufacture of plate-glass at Ravenhead in Lancashire, where it has ever since been carried on by the "Governor and Company of British Plate-Glass Manufacturers." Since then other large establishments of a similar kind have been formed, but the number of them always has been, and still is, very limited.

Before plate-glass, which is produced by casting, was known, there was a kind of somewhat similar quality produced by blowing, but much smaller in dimensions than can be procured by casting. There is still a kind of glass made, called *sheet*-glass, which is produced in some such a way as the blown plate of former times; and it may be therefore well to speak briefly of it here. In making sheet-glass, the workman gathers on the end of his tube the requisite quantity of melted glass, and rolls and blows this until it assumes the form of a hollow globe eight or ten inches in diameter. This globe is swung to and fro, then heated, then again swung, and so on until it is brought to the form of a cylinder three or four feet long by eight or nine inches in diameter (Fig. 718). This is in every respect a most remarkable process; for, instead of transforming the globe of glass to a flat sheet, as is the case in crown-glass making, the workman transforms it into a cylinder. That the hollow globe of glass would elongate when held downwards in a soft state, may be readily conceived; but to manage this elongation so as to produce a regular and equal cylinder, is an operation requiring very great skill. When the cylinder is produced, means have to be adopted for separating it from the tube and opening the two ends, which are still closed and hemispherical; and this is done in a manner as curious as the other parts of the process. The tube is stopped up with the thumb or finger; the cylinder is held near a furnace, and the air which is cooped up in the cylinder and tube, being expanded by the heat, forces for itself a hole at the extreme end of the cylinder, which hole, by heating and rotating, expands to the same diameter as the cylinder. The rod is then separated from the other end, and that end made even and square. The next point is, to open this cylinder so that it shall form a flat square sheet. To effect this, a hot iron wire is drawn along the interior of the cylinder from end to end; this makes a fissure in the glass, and by placing the cylinder in an oven with this fissure uppermost, the glass, as it softens by the heat, falls down by its own weight, and lies flat on the floor of the oven in the state of a square sheet. While in this state it is rubbed with a piece of charred wood fixed to the end of a handle, to make it smooth, flat, and even, and is then placed upright in an annealing-oven.

The modern *plate*-glass, however, is made in a very different way. The casting-house is in every respect cleaner and better ordered than the buildings where crown and flint-glass are made. There is a central furnace or group of furnaces; a wide open space surrounds or nearly surrounds this; and the open space itself is bounded by large annealing-ovens. One part of the open space is occupied by the *casting-table*, a large piece of apparatus forming the most important feature in the arrangements: it consists of a very carefully prepared iron plate, in some cases sixteen or seventeen feet long by nine or ten wide, and provided with a number of subsidiary arrangements.

The ingredients for plate-glass, as for flint-glass, comprise mainly sand, alkali, and lead; but each establishment has its own particular recipe for the materials as a whole. When mixed they are "fritted" as for crown-glass; that is, they are partially melted together in small furnaces before the proper or thorough melting. Being afterwards melted in the clay pots (which differ somewhat both in shape and in the mode of arrangement in the furnace from those for flint-glass), the fiery liquid undergoes a remarkable and careful examination before being pronounced fit for use. A copper ladle, attached to a handle held by three men, is passed in at the mouth of the furnace and dipped into the melting-pot: a small quantity of glass is taken up, and is poured from the ladle out upon a small flat slab or tray (Fig. 719); when cooled a little, the mass or flat layer of glass is examined by a workman, whose duty is to remove any defective or ill-conditioned portions. By experience he knows whether the appearance of the mass is such as it should be, and he removes any discoloured spots (for every defect influences the colour in some way or other) with the pointed end of a rod. The examined portion is then returned to the furnace and put into a melting-pot different from the one which it before occupied; and so the workmen proceed, examining one tray-full after another, and not allowing a single fragment of glass to be used in the casting until it has been examined in a liquid state in this way.

When sufficient glass for one casting has been thus examined and melted, preparations are made for producing a large sheet of glass from it. The mass is allowed to cool slightly from the liquid state, so as to acquire a paste-like consistency. A vessel called a *cuvette*, capable of containing enough glass for one casting, has been kept in the furnace by the side of the melting-pot sufficiently long to become red, or rather white, hot; and while in this position it is filled with glass by means of a ladle introduced through the opening of the furnace, a process which exposes the workmen to an intense degree of heat. When filled and in a proper state, the cuvette is drawn out of the furnace by means of a crane, and is adroitly swung round so as to be brought over the casting-table. Several men, from twelve to twenty in number, now assemble round the casting-table, each to undertake a particular duty in the process which is to follow. At a given signal from the foreman or manager the cuvette is tilted up, and the whole contents flow out like a stream of molten gold (Fig. 720), spreading out on all sides upon the surface of the table. This operation presents a very beautiful appearance to the bystander; for the whole of the surrounding objects exhibit a strong contrast of light and shade from the brilliant glow arising from the melted glass. There is a roller resting on two ledges on opposite sides of the table; and this roller is worked to and fro by some of the men, in order to spread out the glass to an equal thickness all over the table. The table is laid perfectly horizontal, and the quantity of glass used at once is never more than it can conveniently hold to a certain depth or thickness.

The glass remains but a very few minutes, or perhaps we may say seconds, on the table after it is cast. The surface presents, when the roller has passed over, a beautiful play of rich colours, arising from a slight oxidation by the coolness of the iron. The casting-table is so placed that one end of it is close to the oven in which the glass is to be annealed; and on opening the door of this oven, the plate of glass, solidified though still quite hot, is dexterously slipped off the casting-table into the oven, the bed or floor of which is on the same level as the surface of the table. The plate remains here for several days, the heat of the oven being gradually lowered throughout the whole of the time, until at length the plate can be taken from it quite cold.

The plate of glass thus produced is a very different object from that which we are accustomed to recognise as such: it is ragged at the edges and rough at the surface, and this surface requires to be ground and polished before being fitted for its ultimate purpose. In grinding the glass each plate is cemented by means of plaster of Paris to a flat bed or frame, and two such frames are inverted one over another, so that two plates of glass may be in contact. Sand or ground flint is introduced between the plates, and the upper one is so connected with machinery as to have a circular motion given to it. By this arrangement the upper surface of the lower plate and the lower surface of the upper plate mutually grind each other; and when this has been carried on to a sufficient extent, the sides of the plates are reversed, until at length both surfaces of both plates have been ground smooth. The object of this polishing is to remove not only the wavy irregularities of surface which the glass before presented, but also any specks, air-bubbles, or other defects which may have entered within the surface; and to afford the means of doing this, the plate is cast, in the first instance, nearly twice as thick as it is required finally to be.

The glass, though ground to a flat and perfectly level surface, is not only dull or unpolished at the surface, but is full of scratches arising from the use of the sand. These scratches are removed by the use of emery-powder of several different degrees of fineness, beginning with the coarsest, and ending by the use of powder so fine that the glass, though still dull, is beautifully smooth at the surface. Lastly comes the polishing, which is effected in a singular manner:—A number of oblong pieces of wood are covered with cloth and touched at the surfaces with a sort of polishing-paste; and these are attached to a frame or machine susceptible of a horizontal movement. The plate of glass is placed upon a flat bed, and these polishers are worked over it for a long time, until a brilliant polish is given to every part of the surface of the glass.

By such means, then, is a piece of plate-glass produced; and when it is considered that such plates have sometimes been made twelve or fourteen feet long by eight wide, almost spotless in every part of the surface and substance, a slight conception may be formed of the extreme care and delicacy required in the manufacture.

If such a plate of glass be required for glazing a window, or any analogous purpose, it is used in the state to which we have traced it; but if it is to form a "looking-glass," it is coated at the back with a metallic film in a very curious manner. There is provided a very flat table of slate or some other hard smooth stone, and the bed of this table is capable of being adjusted either horizontally or with any required degree of slope. On this smooth bed is laid a piece of tin-foil, and on the foil is poured a quantity of mercury or quicksilver from the iron bottles in which that metal (the only one which is in a fluid state at ordinary temperatures) is usually kept. When the surface of the foil is wholly covered with mercury, the plate of glass (made as clean as possible) is dexterously slid upon it in such a way as to remove all air-bubbles from between the glass and the metal. There are thus, first, the stone table, then the tin-foil, then the mercury, and then the glass; and lastly, upon this last are placed a large number of weights, so ponderous in the whole as to endanger the glass, were it not, as well as the table beneath, perfectly flat and even. By this pressure all the superfluous mercury is squeezed out from between the plate and the foil, leaving only an extremely minute film of the liquid metal. A sort of chemical action then takes place; the mercury and the tin-foil combine to form a united substance or "amalgam," and this amalgam adheres pretty close to the surface of the glass. After remaining in a slightly inclined position for a few days, the weights are removed, and the plate of glass is taken up with the amalgam adhering to it, and forming a brilliantly reflecting surface when seen through the thickness of the glass. The plate is placed up on edge and allowed so to remain until all the fluid mercury which still remains may slowly find its way out from between the glass and the amalgam; and when this object is attained, the "silvered glass," as it is somewhat incorrectly called, is ready for use. There has been recently devised a mode of applying real silver to this purpose by means of galvanic agency; but it is at present only a scientific curiosity, not a commercial process.

Glass-making: Bottle and Phial Glass.

One more kind of glass remains to be described before this part of our subject is finished: it is that in which the glass is *cast in a mould*, in order to produce the object in view. Nearly all kinds of bottles are so made, and cheap substitutes for "cut-glass" are now largely produced by similar means.

In all such cases there is a mould, made either of

brass or of iron, hinged in such a manner that it can be opened into two halves, so as to form a closed mould when the casting is going on, and to be capable of opening when the cast is to be removed from within it. Let us suppose that a small bottle, such as is used for perfumery and similar purposes, is to be made. A workman takes a hollow tube, dips the end into a pot of melted glass in the furnace, works this about on a flat iron plate until it assumes a cylindrical form, and pinches it at a particular spot to form a narrow portion for the neck of the bottle. He has at his feet a brass mould, such as is represented both open and closed at the lower part of Fig. 721. He opens the mould, inserts the mass of white hot pasty glass into it, closes the mould by means of a string held in his hand, and blows through the tube (see upper part of the same cut). The effect of this is, that while the blowing gives hollowness and form to the *interior* of the mass of glass, the mould within which it is confined determines the size and form of the *exterior*. The mould is then opened, the bottle taken out, and after being detached from the iron tube, is finished at the mouth and neck by another workman by a few simple touches with equally simple tools.

Such bottles as those here alluded to are generally made of flint-glass, as being of finer quality; but the large mass of such articles, used for containing wine, ale, and similar purposes, are made of coarse green glass, much cheaper in its composition. The workman, as in other instances, gathers on the end of a tube a sufficient quantity of melted glass, and rolls the mass on a piece of stone or iron, blowing through the tube at the same time, and elongating a portion of the mass of glass so as to form a neck for the bottle (Fig. 722). The mass, as in the former case, is inserted into an opened brass mould placed on the floor; and when thus fashioned, partly by moulding and partly by blowing, the bottle is removed, and is quickly finished by another man.

Having thus traced the manufacture of the various kinds of glass, we may next notice the

Materials and Forms of Windows.

We must be prepared to depart from some of the usages of our own time and country to understand what has been done, and what is now done in some countries, in the mode of providing windows to a house.

In the Greek and Roman buildings, whether temples or dwelling-houses, windows were so few as to form scarcely a feature in the structure; while in all buildings partaking in any degree of the Gothic or of the "Elizabethan" character, the windows are among the most characteristic parts of the whole structure. Indeed, a writer on architecture has observed that "Windows in the Gothic are so characteristic by their general forms and proportions, as well as their decoration and details, as to be in that style equivalent to what the 'orders' are in the temple architecture of antiquity. Gothic without windows would be as deficient in expression as Grecian architecture without columns. Grecian architecture, on the contrary, hardly admits windows, since, instead of adding to, they rather mar its expression, and detract from its character. There are indeed some examples of windows both in Grecian and Roman buildings—for instance, in the Erectheium at Athens and the Temple of Vesta at Tivoli—yet no more than barely to serve as authorities, and to show how apertures of the kind were designed. Besides being of exceedingly rare occurrence in classical architecture, the windows themselves were very few in number, and never placed so as to form more than one tier or story of them; consequently the effect was totally different from that attending two or more continuous ranges of windows placed one over the other. In fact, however well they may be designed in themselves, it is almost impossible to reconcile windows, at least any great number of them, with columnar compositions."

The windows here alluded to as being used sparingly in classical buildings were simply openings to admit light and air freely. The closing of such apertures with glass or any other transparent material is a contrivance rather more modern in its date. Many substances have been used for this purpose, but none equal to glass in efficiency and beauty. Thin slabs of marble, talc, oiled paper, all have been used at different times and among different nations; but glass, wherever it can be procured at anything like a reasonable rate, is everywhere preferred.

The houses of Oriental countries exhibit very little indication of glass windows. The climate being warm and clear, there is not that necessity for protection from rain and cold which has so much effect in our own country. The houses, as we have before had occasion to remark, rarely have any look-out towards the street. There is an open court, or something analogous to it, either behind or in the centre of the house, and the windows generally look into this court. The custom of living and smoking and sleeping on the housetop, so different from anything known in our own country, affords another reason why very little attention is bestowed upon the construction of windows to the apartments beneath. A shady veranda to keep off some of the intensity of the sun's heat is much more acceptable in warm climates than a glass window, since the latter would keep out whatever welcome breeze there might be, rather than improve the temperature and state of an apartment.

The windows of Cairo in Egypt may be taken as a curious example of a style differing greatly from our own, and deriving its character both from the jealous seclusion of Mohammedan habits and from the warmth of the climate. The windows of the upper apartments, looking into the narrow streets, project half a yard or more from the front of the house, and consist mostly of very close carved lattice-work, such as is shown in four or five specimens in Fig. 723. It generally consists of a sort of globular or egg-shaped bead connected by cross or diagonal bars: the distance from the centre of one bead to that of another being about an inch and a half. This degree of closeness is such that much of the sun's light is excluded, a view of the interior from without is prevented, while fresh air can be admitted. In a former cut (Fig. 621) the form of these windows is indicated; and in the cut now under notice 6 represents the side of such a window, of which the part A is usually occupied by lattice of the kind marked 1, the part B by lattice of the kind 2 or 3, while C is a small lattice capable of opening on hinges, and of the kind 4 or 5. Some of the projecting windows are constructed wholly of boards, and a few have frames of glass in the sides. In the better houses the lattice windows have glass frames within them, to be used or not, according to the temperature of the weather. In other kind of houses the windows are differently formed, being on a level with the exterior wall of the house, instead of projecting: the upper part is of wooden lattice-work, while the lower is closed by hanging shutters. In the best houses, besides the windows of lattice-work, the upper rooms have others of coloured glass, representing bunches of flowers, birds, and other gay objects, or merely fanciful patterns. These coloured glass windows are mostly about two feet high by somewhat less in width, and are generally placed along the upper part of the projecting lattice-window in a row. They are composed of small pieces of glass, of various colours, set in rims of fine plaster, and enclosed in a frame of wood.

Respecting the early use of glass windows in England, Mr. Porter, in his 'Treatise on the Glass Manufacture,' remarks: "Long before the establishment of the manufacture within this island, glass was known and used in England. The Venetians, who traded with this country in very remote times, furnished this among other articles of commerce in exchange for tin. The erudite Pennant is of opinion that glass-making in Britain dates prior to the Roman invasion. The Druids were accustomed to impose upon their more credulous followers by means of clumsily formed beads of coloured glass, which they pretended were endued with the quality of guarding their possessors from evil. The venerable Bede, who lived very near the time, and who therefore had good opportunities for ascertaining the fact, has asserted in his 'History of Weremouth' that in the year 674 the Abbot Benedict sent for artists from beyond seas to glaze the windows of the church and monastery of Weremouth in Durham, and that these men were our first instructors in the art of making window-glass. This art, however, took root but slowly among us; and it was not until the eleventh century that glass windows were at all commonly used, either in private dwellings or in public and religious edifices. Previously to this time light was imperfectly transmitted through linen cloths or wooden lattices. The houses of the commoner people were not, indeed, furnished with this luxury until the thirteenth or fourteenth centuries, in which respect our ancestors were greatly behind the inhabitants of Italy and France."

There is a very curious record still existing, showing that even in the latter half of the sixteenth century, and among the highest and wealthiest nobility, glass windows were a choice portion of house-fittings. This record is the 'Northumberland Household-Book,' in which is given, among the minutes of a survey of Alnwick Castle made in 1567, the following: "And because throwe extream windes the glasses of the windowes of this and other my lordes castels and houses here in the country dooth decay and waste, yt were good the whole leightes of everie windowe at the departure of his lordshippe from lyinge at anie of his sade castels and houses, and dowring the time of his lordshippes absence or others lyinge in them, were taken downe and lade up in safetie; and at sooch time as ether his lordshippe or anie other sholde lye at anie of the sade places, the same might then be set uppe of newe with small charges to his lordshippe; whereas now the decaye thereof shal be verie costlie and chargeable to be repayred."

As late as the year 1660 the windows of the ordinary country-houses in Scotland are said to have been unglazed; even in the king's palaces only the upper parts of the windows had glass, the lower ones having two wooden shutters to open at pleasure and admit the fresh air.

It is singular to remark the richness of the windows in old English mansions in past times, compared with anything which our modern arrangements can exhibit. Let us look, for instance, at the windows of houses constructed in the fifteenth century (Fig. 724), or at the bay-windows of the old palace at Greenwich (Fig. 725), or at London windows in the time of James I. (Fig. 726), or at the windows in Cheapside as still existing a century ago (Fig. 727); in all of these we find a richness of form, or of filling up, or of decoration, such as our modern builders rarely think of supplying. This is a point in which many architectural critics think that we have by no means improved on our forefathers. A writer in the 'Penny Cyclopædia,' while speaking of the effects which openings have upon the appearance of a building, observes, "Every sort of aperture, whether for a door, a window, or a fire-place, requires to have 'dressing,' or border to it, otherwise it looks unfinished and incomplete, and the effect to the eye is as unsatisfactory as would be that of a picture hung up without a frame. If, then, there is to be any degree of enrichment, or even of mere architectural finish, and the expression derived from it, doors and windows claim it in the first place. Unless decoration be bestowed upon them, instead of being features in the design, they will show themselves only as blemishes; and in proportion as ornament is applied elsewhere, the whole will become incongruous patchwork. The principle to be attended to is so generally disregarded, and its being neglected has occasioned such a false and vicious system of architectural design, that it cannot be too strongly inculcated and enforced. Adam's (the architect of several London streets some years ago) buildings are most striking instances of the faulty practice of leaving windows mere naked apertures, while even excess of decoration is affected elsewhere; hence his festoons, panels, pilasters covered with arabesques, and other things of that kind, look no better than mere frippery. Even now, when it has become more general to bestow some sort of dressing on windows, there is seldom that study given to them that could be wished; either the dressings are meagre or tame and insipid, and the windows are not so much the architect's own composition, as patterns appropriated by him from the common stock, and applied perhaps nearly at random." The same writer further remarks that the general architecture both of London and Paris, even in the best streets, is very poor, owing to the windows being so numerous and so closely crowded. "There is a prejudice against wide piers between windows in this country, as being suited only for a southern climate, where shade is desirable; but narrow piers are equally unsuitable for a northern one, since they cause a room to have a cold, unsheltered look at inclement seasons of the year. Some have attempted to lay down rules for proportioning the superficial area of the openings or windows of a room to the cubic space of the room; but besides being rather fanciful in itself, this cannot be consistently followed or practised, because the size of windows and breadth of piers determined upon for one room must be adopted for all those in the same front—at least upon the same floor. Nicety of that kind would require that in a north or north-east aspect the relative proportion of windows and solid wall should be very different from that adapted for a southern one, and be made also to vary according to the actual situation of the building with regard to others, since, with respect to light, it certainly makes a very great difference whether rooms face a narrow or a wide street, and whether the opposite buildings be lofty or low."

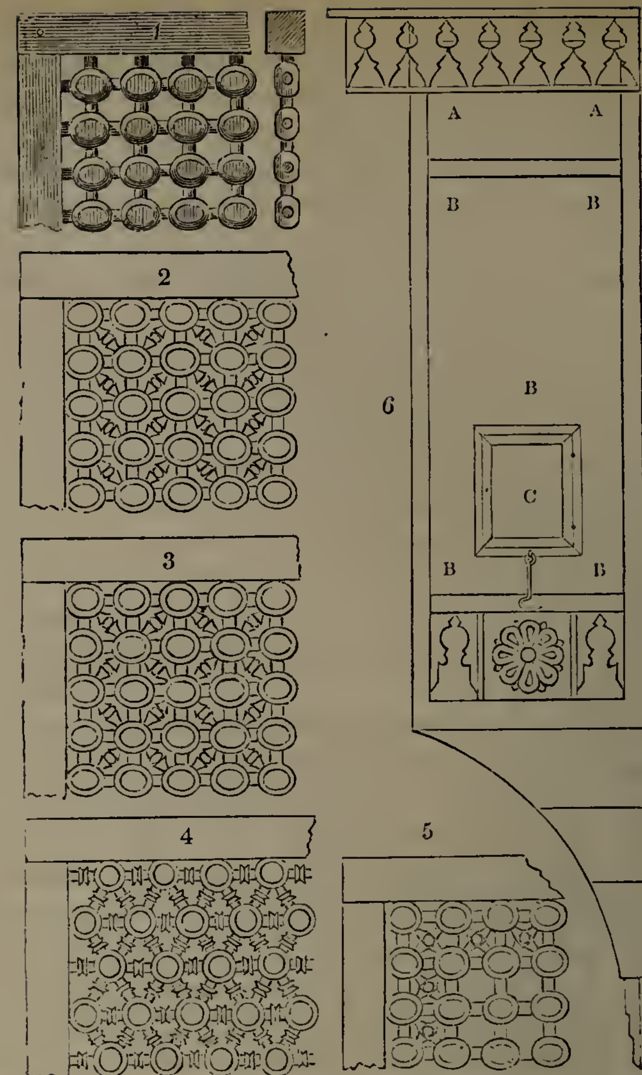
Without at all depending on matters of taste, many windows derive their chief character from the kind of occupation carried on within the room lighted by the window. A curious illustration of this is afforded in the humble streets inhabited by the silk-weavers in Spitalfields and Bethnal Green. In some of these streets every house, and in a large number of others almost every house, is provided with such windows as are sketched in Figs. 728 and 729. In almost every room so lighted there is a loom for weaving silk; and as the loom is rather a large piece of apparatus, and as a good deal of light is required for the operation of the weaver, the window is made to extend nearly the whole width of the room. In some houses, these wide windows, glazed with small diamond-shaped panes of glass, are provided for the upper rooms only, while in other houses the whole of the floors, being similarly occupied by weavers, are lighted in a similar manner.

Various minor features relating to the form and material of windows we may pass over unnoticed, but a little attention must be directed to the beautiful art of making

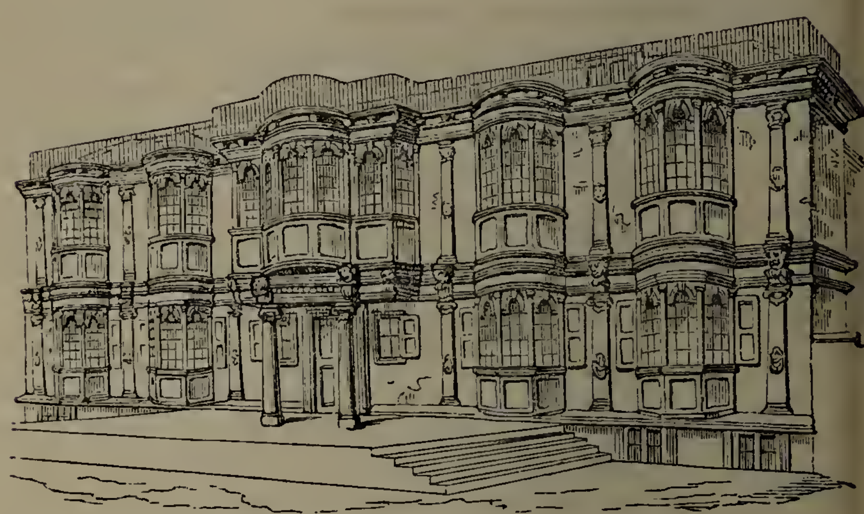
Windows of Stained Glass.

The production of stained or coloured glass is, in one respect, the easiest department of the art, since it is very difficult to produce glass without colour. Arsenic, antimony, and other substances are mixed with the ingredients for glass, as a means of removing the greenish tinge which it would otherwise present. But the art of so managing the details that the glass shall have a definite colour, and of a definite degree of

726.—London Windows: Time of James I.



723.—Lattice-work of Egyptian Windows.



725.—Bay Windows of the Old Palace at Greenwich.

728.—Silk-weavers' Windows, Spitalfields.

727.—Windows in Cheapside 1750.

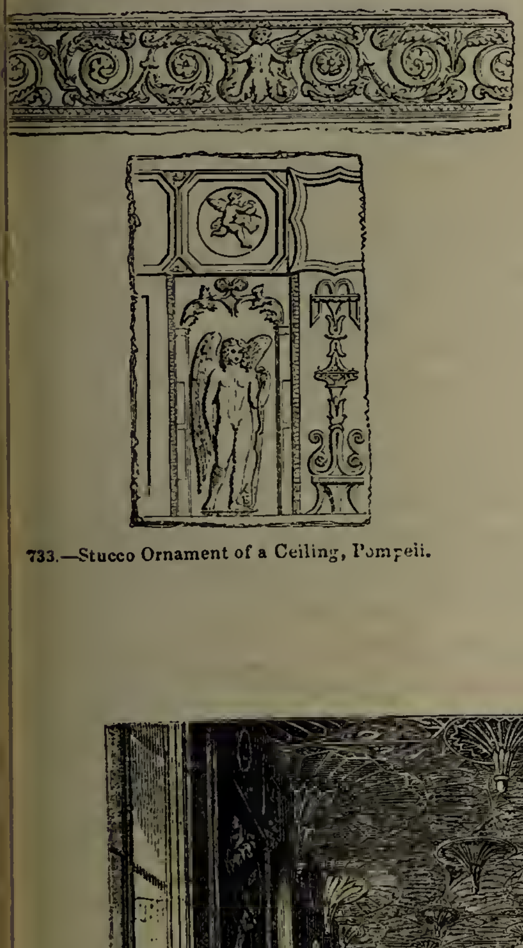
724.—Windows: Fifteenth Century.

729.—Silk-weavers' Windows, Spitalfields.

731.—Decorated Wall of a Room, Pompeii.

730.—Style of decorating Ancient Roman Apartments.

732.—Mode of hanging a Picture, Pompeii.



733.—Stucco Ornament of a Ceiling, Pompeii.

736.—Pattern for Paper-hangings.

734.—Interior Decorations: Gallery at Strawberry-hill.

735.—Interior Decorations: Library at Strawberry hill.

intensity, is certainly the most difficult one that the glass-maker has ever undertaken.

The rudest idea of forming an ornamental subject in coloured glass would be to take a number of small pieces of different colours and arrange them side by side in a definite pattern. When such pieces are of very small dimensions, the work would constitute a species of delicate mosaic; and an extraordinary specimen of such work has been described by Winckelmann. This was a small piece of mosaic representing a duck, and was wholly produced by laying little rods or pins of glass side by side, the colours being various, and disposed in proper order. Winckelmann says of this specimen:—"The outlines are well defined and sharp, the colours beautiful and pure, and have a very striking and beautiful effect, because the artist, according to the nature of the parts, has in some employed an opaque and in others a transparent glass. The most delicate pencil of the miniature painter could not have traced more accurately and distinctly either the circle of the pupil of the eye or the apparently scaly feathers on the breast and wings. But the admiration of the beholder is at the highest pitch when, by turning the glass, he sees the same bird in reverse, without perceiving any difference in the smallest points; whence we could not but conclude that this picture is continued through the whole thickness of the specimen, and that if the glass were cut transversely, the same picture of the duck would be found repeated in the several slabs: a conclusion which was still further confirmed by the transparent places of some beautiful colours upon the eye and breast that were observed. The painting has on both sides a granular appearance, and seems to have been formed, in the manner of mosaic-work, of single pieces, but so accurately united, that a powerful magnifying glass was unable to discover any junctions." The mode in which such exquisite specimens of art as these are supposed to have been produced is as follows:—Slender glass rods or pins being selected and arranged in the proper order of colours, they were laid side by side in the manner of types, and were then gently fused at the surface to cause them to amalgamate; supposing, however, that this was really the mode, a rare amount of delicacy and skill must have been required to melt away, as it were, the lines of junction, without allowing one colour to run into another.

The general mode of making stained glass for windows is, however, very different, and has undergone many changes in successive ages. As far back as a thousand years ago, the ecclesiastical edifices had frequently windows of painted or stained glass. The earliest were such as we have before alluded to, viz., small pieces of differently coloured glass connected edge to edge with some kind of cement, and so selected and arranged as to present some sort of pictorial effect—a mode of proceeding which rendered the production of delicate effects wholly unattainable. The next stage was to *paint* the subject of the picture on the surface of pieces of glass, and it was not until a much later period that the art became known of so burning the colours into the glass as to form a sort of combination of the two arts of painting and staining.

The art was practised in France and Italy earlier than in England. English ecclesiastical buildings, up to the time of King John, were supplied with their painted windows from the Continent. A curious record is still preserved concerning the great east window of York Cathedral. John Thornton, a glazier and glass-stainer of Coventry, was employed to paint this window, in the time of Henry IV.; he was to receive wages amounting to four shillings per week—rather a high rate at that time, awarded to him because he was a "masterlye workman:" if he finished his work in three years, he was to receive one hundred shillings per year additional; and on its completion, if his work was approved, he was to receive another extra sum of ten pounds.

From that time to the time of the Reformation, a great many fine specimens of stained glass were produced; and although the art received a great check from the change of religious feeling that occurred at that time, it revived afterwards, though it is doubtful whether it will ever again be regarded as of so much importance as in earlier times. Several very clever specimens were produced within the last two centuries; among which are some of the windows at Queen's College, University College, and Wadham College, Oxford, executed by Linge about two centuries ago; the windows of All Souls, of Christ Church, and of other Colleges at Oxford, during the first half of the last century, by Price, Ollivier, and Marlow; the windows of Arundel Castle, of Magdalen College, of some parts of Windsor Castle, of St. George's Chapel, Windsor, of New College at Oxford, were either painted or restored during the last century. The present century, too, has not been without very splendid specimens of this art. Messrs. Headly and Oldfield have produced copies from pictures of an elaborate class; such as the 'Belshazzar Feast,' the 'Nineveh,' and the 'Joshua' of Martin; the 'Kemble Family' of Harlowe; the 'Faith,' 'Hope,' and 'Charity' of Reynolds; the 'Descent from the Cross' of Spagnoletti, &c. The revival, within the last few years, of a style of ecclesiastical decoration and fittings partaking of the richness of early cathedrals and abbeys, has given a new impetus to the labours of glass-stainers, many of whom are now engaged on windows for various new churches.

In the processes by which stained glass is produced, metallic oxides and other chemical substances are introduced with the ingredients necessary for making glass itself, if the glass is to have one uniform tint all over; but if varying tints are required, certain ingredients are applied at the surface, and then burnt in. Some very fine ornamental effects—not so much in the stained-glass as in the flint-glass manufacture—are produced by combining coloured with colourless glass. There are two pots of melted metal, one containing colourless glass of the usual kind, and the other containing glass which has been coloured by certain chemical agents. The workman first dips a rod or tube into one pot, gathering pretty nearly enough of the colourless glass for his purpose; and then dips it into the other, whereby a thin film of coloured glass is applied as a coating to the former. By subsequent management this coloured film may be more or less renewed, so as to produce ornamental effects of a very delicate kind. Sometimes a thin film of coloured glass is enclosed between two films of colourless glass, by similar means, three vessels of melted glass being used instead of two.

It has been a very important feature in the glass-stainer's art to find out what chemical agents will produce the desired colours and shades of colours. In some instances the old windows present a richness of colour which almost defies the skill of the modern artist to imitate; a circumstance which may perhaps be due to the mellowing effect of time. Silver is an important agent in the production of yellow and orange-coloured glass. Cobalt or zaffre is the chief means for producing blue. Green is produced by staining the glass with blue on one side and with yellow on the other; the combined effect of the two, when seen by transmitted light, being that of a green colour, the character and tint of which depend mainly on the tint of yellow employed. Gold will aid in the production of a yellow colour. Gold and silver, used in combination, produce a rose-colour; iron gives a brightish red; while the same metal, combined in various proportions with copper or manganese, or both, produces innumerable tints, varying in all the shades of brown from red to black. Some of these colouring agents have been the subjects of curious anecdotes in connexion with the past history of the art. About the period of the commencement of the French Revolution, so strong was the desire to ransack for gold among any or every object which had before been held sacred, and so firm the opinion that the old glass-stainers employed a good deal of gold in producing their colours, that the government actually ordered a quantity of fine old red glass to be melted up, with a view to the extraction of the gold from it; a project which brought neither honour nor profit to its authors. In another case an accidental circumstance led to the observance of the fact that copper will produce a red stain in glass. We have before stated that, in making plate-glass, the whole of the glass for one casting is poured out upon the casting-table at once; but at a former period it was customary to pour the melted glass by ladlefuls out of the melting-pot upon the casting-table, dipping the copper ladle into cold water from time to time to prevent it from being melted. On one occasion, at the plate-glass works of St. Gobain, in France, a workman having negligently left the copper ladle in the white-hot contents of the melting-pot, he found some time afterwards that the ladle had melted away, and had produced beautiful red streaks in the mass of melted glass. This circumstance is said to have led to the introduction (or perhaps only to the revival) of the use of copper in producing a red stain on glass.

A painted window is usually built up of two kinds of materials; the one being pieces of stained glass, and the other pieces of painted glass. In a draped figure, for instance, the features and all the minuter details, in which frequent change of colour or tint takes place, are painted; while in broad masses of drapery, where there may be a tolerably large surface of one tint, a piece of glass which has been stained of that tint in the making is used, cut to the requisite size and shape; or the two methods may be used conjointly, by partially painting a piece of glass which had previously been stained of some one uniform colour. When a sufficient number of pieces of the different kinds are prepared, they are placed together edge to edge and formed into a picture; the joints being secured with glazier's lead, and being so chosen in position as to occur at the shaded parts of the picture. In producing the stained glass, the metallic colouring ingredients are thrown into the melting-pot with the sand, alkali, &c.; and sheets of coloured glass are formed from the mixture, in the same way as of colourless glass under ordinary circumstances. To produce the painted glass, the device is properly drawn and coloured on paper, and is fixed down to one surface of the properly shaped piece of glass: it appears then like a drawing seen through the glass; and the artist paints on the outer surface of the glass an exact copy of this picture, following all the lines of the device, and adapting his colours accordingly. These colours are formed of the metals or metallic oxides just alluded to, ground up with flint-glass, oxide of lead, and borax; and moistened with one or more of several liquids, including turpentine, amber oil, capivi balsam, and gum-water: the metallic agents give colour; the flint-glass, lead, and borax enable the whole to be fused or vitrified; and the liquids enable the painter to apply the colours.

When the required device or picture is thus painted, the piece of glass is exposed to a degree of heat sufficient to fuse the paint, and convert it into a kind of glass, which combines with the substance of the glass on which it is laid. The piece of painted glass is placed in an iron box called a "muffle," in which it is rested on iron shelves covered with powdered lime to prevent adhesion. The muffle is then placed in a furnace heated with coke or charcoal, and exposed to a heat which requires to be managed with a high degree of care and skill: the glassy paint (for so we may term the material with which the device is painted) is just wetted sufficient to be vitrified and to combine with the glass beneath: a temperature either a little above or below a particular point being likely to spoil the whole operation. There are hollow tubes so inserted in the sides of the furnace, that the operator can look through them and see how the process advances. When brought to a conclusion, the fire is allowed to die away gradually, and the piece of glass is removed from the muffle. Part only of the colouring ingredients have been absorbed into the substance of the glass; the rest are scraped off and preserved to be used again (for many of the colours employed are very valuable). If, when examined, the glass exhibits defective places or wrong tints, it is partially touched again, and again exposed to the heat of the oven. A great part of the stainer's art consists in this—that the colours as they appear on his pallet do not accord with those afterwards seen through the painted and stained glass when burnt in, so that there is a kind of "guess-work" as to the result of his labours, such as is not encountered by the artist who paints with oil-colours upon canvas.

In two of the coloured illustrations to 'Old England' are representations of stained windows still existing, giving some idea of the brilliant colours employed in this art, however odd may in some instances be the kind of drawing exhibited in the copy. One of these is a window painted for Brereton Hall, in Cheshire, but afterwards removed to Aston Hall, in Warwickshire. It represents two of the Saxon earls of Mercia, and seven of the Norman earls of Chester. It is remarked, in the description of this plate, that "In the painted window it will be observed that each figure is placed within an arch. Each arch in the original window is seventeen inches in height, and about eight in width between the columns. The arches are struck from two centres, and have a keystone on which is represented a grotesque head under a basket of fruit. It will of course suggest itself to the reader that this window, being in all probability executed in the time of Elizabeth, cannot be received as a perfectly faithful representation even of the costume of these redoubted vice-kings of the county palatine. Upon this point Ormerod has the following remarks:—"The style of the architecture is of the era of Elizabeth; but an erroneous idea prevails as to the high antiquity of these figures, and as to their having been the identical representations of the earls which formerly graced the windows of Chester Abbey." To correct this idea, the county historian refers to a rude drawing in the Harl. MS. 2151, which shows the character of that ancient glass; but he adds: "It is, however, not unlikely that the figures may have been copied from paintings, stained glass, or monkish illuminations, of considerable antiquity; though the paintings themselves were most probably executed for the decoration of the newly erected Hall of Brereton at the close of the sixteenth century." The other coloured plate to which we allude above represents a stained-glass window formerly in a house at Betley, in Staffordshire, and supposed to have been worked in the time of Edward IV. It represents a morris-dance—one of the out-of-door amusements of "England in the olden time." There are characters representing the king of May, Maid Marian as the Queen of May, the court fool, a Spaniard and a Moor, a lover of Maid Marian, a Franciscan friar, a peasant, and a franklin or gentleman—all attired in a manner consistent with the characters which they assume.

Generally speaking, however, stained glass windows are employed for ecclesiastical edifices, and are painted with subjects more or less bearing on religion; and associations are thereby so far formed as to create many allusions among our poets to

> "Storied windows, richly dight,
> Casting a dim religious light."

Painted Walls of Ancient Rooms.

The glass which is to form the windows of a room is one of the most important means for giving cheerfulness and elegance to the interior, and, as we have just seen, presents many important varieties and applications. This feature attended to, we are next enabled, by taking a glance around us, to see how largely taste has been exercised in devising means for rendering the ceilings, the walls, and the floors of modern apartments

not only comfortable, but graceful. It is exceedingly curious to mark the wide diversity exhibited by different countries in these matters. Some bestow so great an admiration on the natural grain of many kinds of wood, when smoothed and highly polished, as to prefer these to most other kinds of internal decoration. Some love rather to paint the surface of wood with brilliant colours. Some have patronised rather the graceful folds of tapestried hangings. Some avail themselves of painted paper or of stained leather. Others call in the aid of the artist, to form regular pictures on the ceilings and walls of a room. In this way the materials of the walls themselves, the materials applied as an ornament, and the planning the device, all partake largely of diversity among different nations, ages, and individuals.

Here, as in other cases, we may gain useful information by comparing our own age with ages which are past. Let us first take the ancient Egyptians. Sir J. G. Wilkinson, speaking of the houses of that remarkable people, says that "The walls and ceilings were richly painted, and frequently with admirable taste: but of their effect we can only judge from those of the tombs, where they are preserved far more perfectly than in the houses, few of which retain any vestiges of the stucco, or of the coloured devices that once adorned them. The ceilings were laid out in compartments, each having a pattern with an appropriate border; in many instances reminding us so strongly of Greek taste, that we should feel surprised at finding them on monuments of the early periods of the eighteenth and preceding dynasties, if there was not authority for believing that the Greeks borrowed numerous devices from Egypt; and we may ascribe to the same origin the scarab, the harpy, and several of the ornamental emblems on Greek and Etruscan vases. The favourite forms were the lotus, the square, the circle, and, above all, the succession of scrolls, and square within square, called the Tuscan border, both which are of ordinary occurrence on Greek and Etruscan as well as Egyptian vases. . . . . . That the Greeks and Romans far surpassed the Egyptians in taste, and in the numerous combinations they used to adorn their rooms, is evident; a natural result of the encouragement given to invention, which Egypt, fettered by regulations and prejudices preventing the development of taste and cramping the genius of her artists, never enjoyed; but however the *laqueata tecta* (enriched ceilings) of the Romans surpassed in richness and beauty of effect the ceilings of an Egyptian house, divided as they were into numerous compartments, presenting cornices, mouldings, and embossed fret-work, painted, gilt, and even inlaid with ivory, still in the general mode of decoration they, like the stuccoed walls, bore a striking analogy to those in the mansions of Thebes and other cities on the Nile."

There are not many other ancient countries whose customs and industrial arrangements have been handed down to us in so singular a manner as Egypt, owing partly to the great love which the inhabitants of that region seem to have had for painting, in many or most of its phases. The other Oriental nations of early times had, if we may believe scattered notices, often costly trappings to their rooms, but of a character only vaguely understood at the present day. There was one people, however—the Romans—concerning whom we are not left so much in the dark, and to whom a little attention must be here given.

The mode of decorating the walls of rooms at Pompeii shows that the Romans had cultivated this branch of decorative art to a notable extent. Besides ornamental devices in stucco and other materials, the walls were frequently covered with paintings. Until the time of Augustus it seems to have been usual among the Romans to paint the walls of houses one single colour, relieved by capricious ornaments; but that emperor introduced as a general fashion, that which had been partially acted on before, viz., the covering of entire walls with pictures and landscapes. In his time is said to have been introduced, by a painter named Ludius, the style of decoration now called "*arabesque*," and the taste spread so rapidly, that specimens of the art are met with in nearly all the ruins of buildings erected about that time, such as those at Pompeii, Herculaneum, and Pozzuoli. When the ruins of these towns were first excavated, many of the buried rooms were called *grotte* or subterranean rooms, and as the paintings in question were found abundantly on the walls of those rooms, the style of painting obtained the name of *grotesque*, by which, as well as by that of *arabesque*, it is known in the arts. It has been observed that Vitruvius was entirely out of conceit with this sort of ornament, as not representing any natural object, but that posterity has overruled his judgment; for the arabesque style of decoration has had a large degree of favour in subsequent ages. Raffaelle is understood to have derived the plan of the Vatican frescoes from the paintings found in the baths of Rome.

Sir William Gell describes a very remarkable style of painting adopted on the walls of some of the rooms at Pompeii: "It is singular that in many cases, though a picture be not ill-preserved, and may be seen from the most convenient distance, a style of painting has been adopted which, though calculated to decorate the wall, is by no means intelligible on a nearer approach. In a chamber near the entrance of the Chalcidicum, by the statue of Eumachia, is a picture in which, from a certain distance, a town, a tent, and something like a marriage ceremony might be perceived; but which vanished into an assemblage of apparently unmeaning blots, so as entirely to elude the skill of an artist who was endeavouring to copy it at the distance of three or four feet. Another picture of the same kind is or was visible in the chamber of the Perseus and Andromeda. An entire farm-yard, with animals, a fountain, and a beggar, seemed to invite the antiquary to a closer inspection, which only produced confusion and disappointment, and proved that the picture could not be copied except by a painter possessing the skill and touch of the original artist. It is probable that those who were in the habit of painting these unreal pictures, had the art of producing them with great ease and expedition, and that they served to fill a compartment where greater detail was judged unnecessary."

The same writer states that this mode of representing the effect of a picture upon a wall, instead of imitating nature itself, is applied with considerable success in the decoration of some of the modern Italian mansions. There is in the Palazzo Samuzzi at Rieti a room of magnificent dimensions, on entering which a visitor imagines himself in an apartment hung with green damask, and decorated with a profusion of splendid pictures. There are Madonnas and Holy Families, landscapes, animals, and battle-pieces, which recall at the moment the names and works of the most distinguished artists. A further examination, on a nearer approach, shows that no one of the objects has any decided form or outline, or intelligible sign. Not only does the whole collection consist in the representation of pictures, but their seemingly gold frames are merely wooden mouldings, roughly painted with ochre, most scantily touched here and there, in the prominent parts, with gilding, to represent the effect of reflected light. Behind each sham picture was nothing but the white wall, and the apparently rich silk hangings consist in a few narrow strips of the stuff between the frames: yet the whole has a good effect.

From the above description we may conclude that this style of pictorial art was either a species of *anamorphosis* or a species of scene-painting. An anamorphosis ("distorted form") is a picture which must be viewed from one single spot alone: if seen nearer or farther, or above or below, or to the right or the left of this spot, it appears at once extravagantly out of drawing, vertical lines appearing to lean to one side, and horizontal lines like inclined planes: indeed not only do they *appear* to be so, but they are really so, and only assume the correct proportions and arrangement when viewed from one single spot. The perspective law which regulates the arrangement of the lines is explained in most of the treatises on optics, and the pictures themselves form a sort of philosophical toy. It is probable, however, that the pictures described by Sir William Gell were specimens rather of the scene-painting art, since the effect does not seem to have depended on the eye of the spectator being exactly at one particular spot, so much as in the circumstance of the pictures being seen at a distance rather than closely, a condition exactly followed in placing the painted scenes at a theatre.

The ancients were acquainted with the modes of painting on wood, cloth, ivory, parchment, and plaster, according to the purposes intended. The last of these was the one applying most nearly to the decoration of the walls of rooms. Many of the rooms were painted in *encaustic*, that is, covered with wax, which was heated after being applied. When one uniform coating of colour was to be applied to a wall in this way, the plaster or stucco was first suffered to dry completely, and then the colour, mixed with wax and boiling oil, was laid on with a brush; a chafing-dish of hot coals was held as near as could be to the walls to "sweat" the wax, after which the surface was rubbed with a piece of solid wax, and finally polished with a piece of fine linen cloth.

Painting in *fresco*, or upon wet plaster, was also practised on the walls of the Roman rooms. In some of the rooms at Pompeii, where detached figures have been painted upon a coloured ground, the partial destruction of the colours has exposed to view the outline, traced upon the wall apparently while wet with a graver. In a painting of the Three Graces, found in a private house in the "street of the silversmiths," there are figures or ornaments painted on a coloured ground; and the entire of this outer or second colour has peeled off in consequence of damp and recent exposure to the air, while the outline remains, cut deep into the background with some sharp instrument.

The houses yet in existence at Pompeii are not in so perfect a state as to show the actual decorations of the walls; yet sufficient evidence is obtainable from various sources to show the general character of the wall-paintings. Thus Figs. 730, 731, 737, 738, 739, will afford a few glimpses in illustration, some copied from specimens actually existing, and others made out from descriptions given by the classical writers. Fig. 732 will give an idea of the manner in which a picture, furnished with a case to close it in when necessary, was suspended against the wall. Figs. 733, 740, show two specimens of stucco ornaments employed in decorating the ceilings of the rooms. Fig. 741 is a part of the painted wall of a kitchen, the subjects being, in part, emblematical of culinary matters.

Before leaving the warm countries of the South, we will notice Mr. Lane's remarks concerning these matters in modern Egypt. He says that the ceilings and walls of the better kind of houses in Cairo are often decked with panel-work of a peculiar kind. The walls of the rooms are generally plastered and whitewashed; but there are frequently cupboards or recesses, of which the wooden doors exhibit many diversities of ornament. On account of the heat and dryness of the climate, the wood of these doors is composed of very small panels, to lessen the liability to warping and shrinkage. This small panelling is so managed as to produce a fanciful effect: seven different specimens are shown in Fig. 743, of which the scale is one inch to about twenty-five or thirty. The reception-room for male visitors has a ceiling of wood, and part of this ceiling is usually decorated by having numerous thin strips of wood nailed upon the planks, forming patterns curiously complicated, yet very symmetrical. In Fig. 744 are shown two specimens of this singular mode of decoration, together with a small portion on a larger scale, to show the manner in which different colours are introduced. The strips of wood themselves are either gilt or painted yellow, while the spaces between them are painted green, red, and blue.

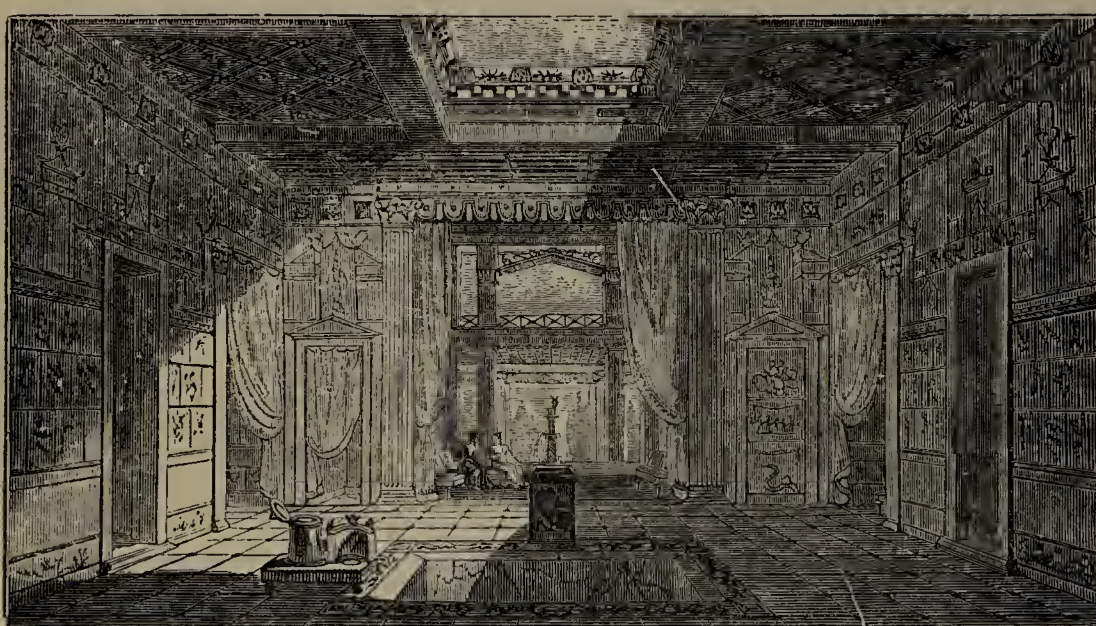
Painting Walls in Fresco.

Allusion has been made above to *fresco* as one of the modes of painting the walls of buildings. This branch of art has lately attracted a good deal of attention in connexion with the proposed decoration of the new palace of the legislature; and it is, when applied to the wall of a room, a common point where the fine arts and the useful arts meet and mutually aid each other.

The word *fresco*, when taken by itself, does not go far to express the meaning attached to it, for it is simply the Italian adjective for "fresh;" but it means a mode of painting on fresh, or damp, or new plaster, in such a way that the colours themselves and the plaster on which they are laid may dry together. In painting in "distemper" the colours are laid upon dry plaster instead of wet, and this single circumstance gives a wholly different character to the labours and importance of the artist in the two cases. Indeed, the extraordinary difficulties of carrying on this style of painting are such that Michael Angelo, who was perhaps the greatest master in it, is reputed to have said that oil-painting, as compared with fresco, was "only fit for women and children." A writer on fresco-painting in Rees's 'Cyclopædia' states in the following clear manner the kind of difficulties which the artist has to contend against:—"From the necessity there is in the progress of this style of art that it should be executed with rapidity, and from the impossibility of retouching it without injuring the purity of the work, the artist, unless he be endowed with very extraordinary powers of imagination and execution indeed, is obliged to prepare a finished sketch of the subject, wrought to its proper hue and tone of colour, and so well digested that there may be no necessity for making any essential alterations in the design. This, which is a very useful mode of proceeding in all fine works of painting, is absolutely indispensable in fresco to those who are not determined to give the rein to their ideas, and leave as perfect whatever may first present itself. There is no beginning in this by drawing in the whole of the parts at one time and correcting them at leisure, as is the custom with oil-painters, who may therefore proceed to work without a sketch: here all that is begun in the morning must be completed in the evening, and that almost without cessation while the plaster is wet; and not only completed in form, but also (a difficult, nay, almost impossible task without a well-prepared sketch) must be performed, viz., the part done in this short time must have so perfect an accordance with what follows or has preceded of the work, that when the whole is finished it may appear as if it had been executed at once, or in the usual mode, with sufficient time to harmonize the various forms and tones of colour. Instead of proceeding by slow degrees to illuminate the objects and increase the vividness of the colours, in a manner somewhat similar to the progress of nature in the rising day, till at last it shines with all its intended effects, which is the case in painting in oil, the artist working in fresco must at once rush into broad daylight, at once give all the force in light and shade and colour which the nature of his subject requires; and this without the assistance (at least in the commencement) of contrast to regulate his eye."

In painting on the surface of a wall in fresco, the artist has to attend to the cartoon, to the preparation of the wall, the preparation of the ingredients and working-tools, and the process of painting. As a means of transferring the exact design to the surface of the wall, a drawing or cartoon is made, the full size

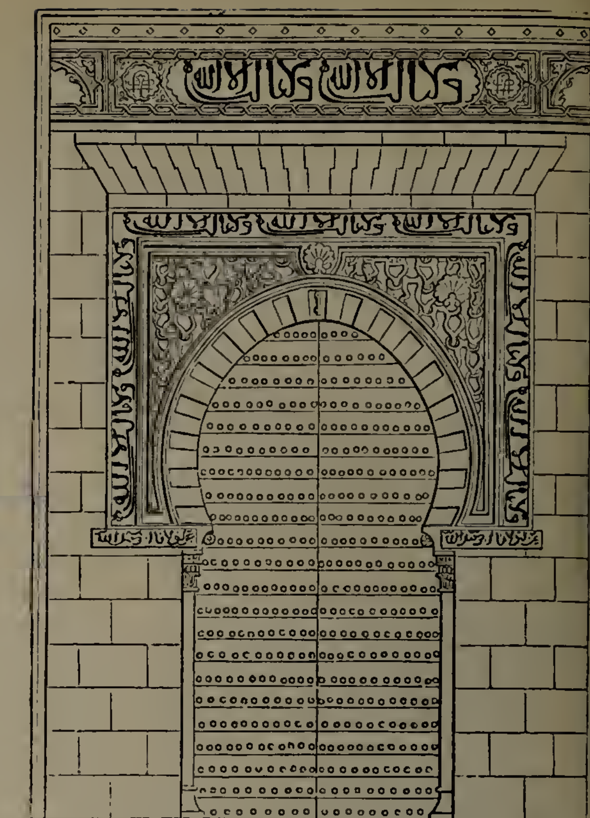
737.—Painted Wall of a Room, Pompeii.



738.—Painted Wall of a Room, Pompeii.

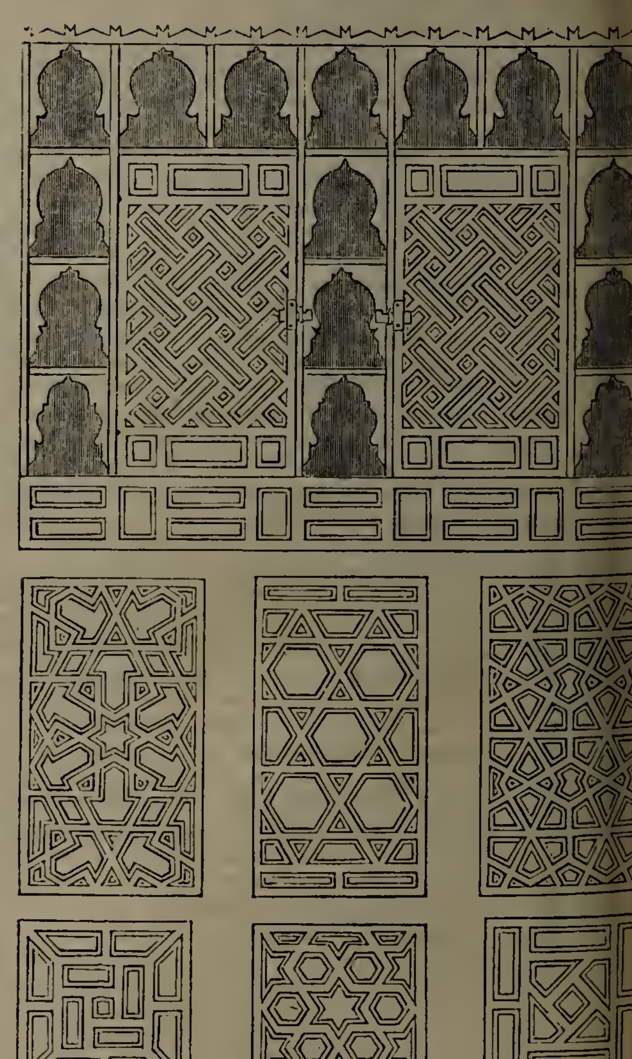
739.—Decorated Wall of a Room, Pompeii.

740.—Stucco Ornaments of a Ceiling, Pompeii.



742.—Ornaments of an Oriental Doorway.

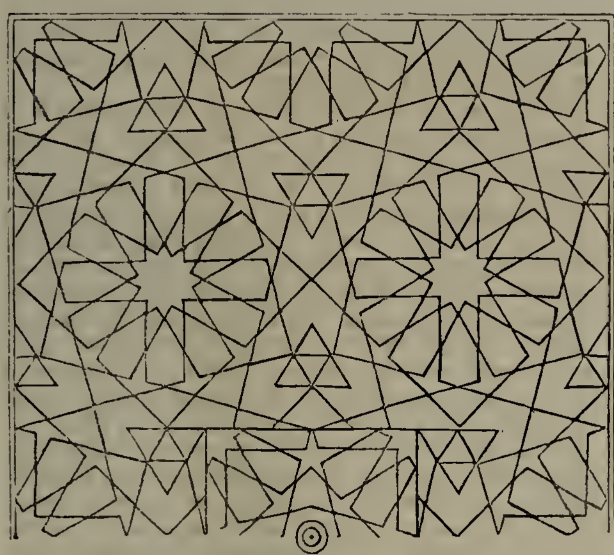
741.—Painted Wall of a Kitchen, Pompeii.

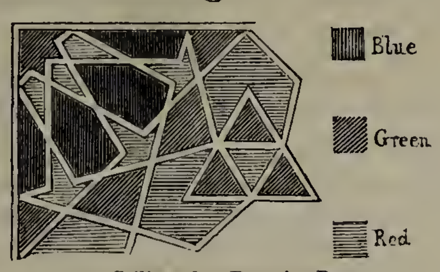


743.—Panel-work of an Oriental Ceiling.

745.—Interior of a Chinese House.

746.—Mosaic Picture, forming a Floor or Pavement at Pompeii.

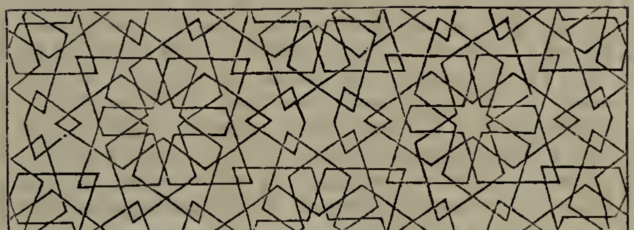




744.—Ceiling of an Egyptian Room.

747.—Specimen of ancient Mosaic.

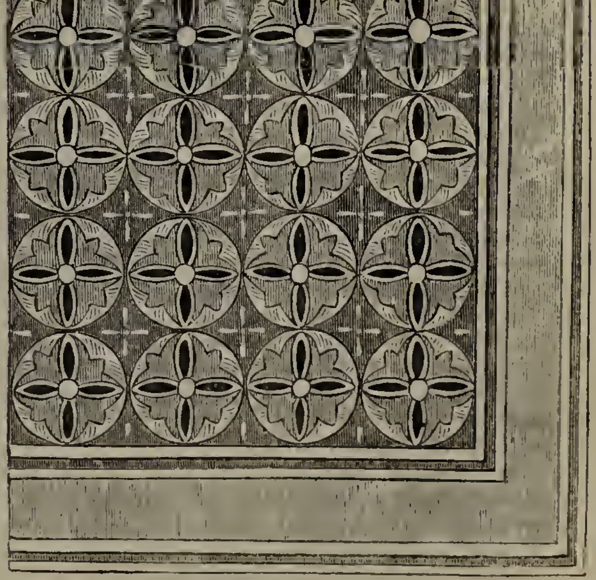
748.—Specimen of ancient Mosaic.



744.—Ceiling of a projecting Egyptian window.

749.—Specimen of ancient Mosaic.

751.—Mosaic Pavement of a House, Pompeii.



750.—Specimen of ancient Mosaic.

of the picture, on paper; and this paper being placed against the prepared wall, the design is pricked through it at the outlines with a sharp instrument, and a little bag of black or red dust is sprinkled over the holes to produce a slightly coloured outline of the device on the surface of the wall.

The wall requires a very careful process of preparation before the painting can be commenced. The foundation must be free from damp, as dampness destroys fresco more than any other circumstance. On the surface of the wall is applied a preparatory coating of plaster, made of well-washed chalk mixed with pounded brick or river-sand, or of some similar materials. When this layer is dry, a second or finishing layer is applied, the surface of the former layer being slightly wetted to insure the adhesion of the two: the second layer is formed of rather different materials from the former, and requires more care in laying on, since it must produce a surface very smooth and even, and be fitted for the reception of the colours which form the picture. Here commence the artist's difficulties: he must not apply more of this plaster at once than he can cover with his paint during the same day, for he must not continue to paint after the plaster ceases to be damp or moist; and in commencing his next day's work, it requires much skill to join the second layer of plaster accurately to the edges of the former. The plaster is laid on with a trowel, and is afterwards smoothed over with the same instrument, a piece of paper being laid between the trowel and the plaster; some artists prefer a slight degree of roughness on the surface, and in such case a dry brush is passed lightly over the wet plaster. The next point is, the nature and preparation of the colours employed. These colours consist wholly of mineral substances, such as chalk and pounded marble for white; vermilion, burnt and unburnt ochres, burnt and raw sienna, Spanish red, &c., for red and brown; ultramarine and smalt for blue, and so on; nearly all the usual mineral colours being employed to a greater or less extent. The colours are finely ground, and mixed with water on a pallet or in small vessels, and they are used with hog's-hair brushes, and with small pencils of otter's hair. There is a peculiarity in these colours and their mode of using, which places the artist in a difficulty not encountered in equal degree by the painter on paper, or ivory, or canvas. In all these three cases the water-colours or the oil-colours employed present nearly the same tint when dry as when wet; but in fresco this is not the case, since all the colours become much lighter when dry than when wet. To be able to tell beforehand, therefore, whether the combination on his pallet will produce the desired tint, the artist usually has at hand some earthy absorbent material, such as a piece of tile, on which he can speedily test the tint produced when dry.

Thus the painter proceeds, applying, on the morning of each day, a certain amount of plaster to the surface of the prepared wall, and painting on that portion, making it an essential point to finish completely that part of his picture before the day has expired. The degree of softness for working is such that the plaster will just receive the impression of the finger, and if it dries a little too rapidly, water is sprinkled on it from time to time. The first tints applied sink in to a certain extent, and present a dead appearance, for which reason the brush is carried two or three times over each part, until a sufficient body of colour has been applied. At the conclusion of the day's work, the plaster is cut round and adjusted in such a manner that the joint between it and the next day's portion may occur at some part of the picture where it may not be visible; and the edge of the former portion is moistened with water when a new portion is plastered, to make the two adhere well at the edges. It is said that the fresco-painters of Munich, who are very skilful in their profession, have a contrivance for arresting the drying of the plaster, in cases where the painting of a particular portion cannot be completed within the day; they place a piece of fine wet linen over the plaster, and press it to the surface by means of a cushion covered with waxed cloth. Damaged or defective portions are sometimes repaired to a limited extent; but it is one of the principles of fresco-painting to leave the picture as much as possible in the state to which each day's work brings it.

Most readers are aware of the circumstances under which this kind of painting has recently come under notice in England. In 1841 a Parliamentary Committee was appointed to report on the best modes of decorating the interior of the New Houses of Parliament, and the subject of fresco-painting, as being adapted to the walls of rooms and buildings, formed part of the inquiry. This style of painting was recommended for adoption; but as it was scarcely known or practised in England up to that time, a Royal Commission was subsequently appointed to inquire how far the skill of English artists was adequate to the object in view. The result of this commission was, that artists were invited to send in specimens of their skill; first, cartoons or drawings for frescoes, and, next, specimens of fresco-painting itself. Two exhibitions, as is well known, were opened in Westminster Hall, as a means of introducing to public view the specimens thus produced; and after being freely criticised, and their merits and demerits considered both individually and relatively, the result was deemed by the Commissioners so far satisfactory as to lead to the decision of having frescoes executed by English painters to decorate certain portions of the walls in the New Houses of Parliament. In a report presented by the commissioners in 1842, Mr. Eastlake gave a mass of valuable information respecting the process itself, and the whole of the circumstances connected with it.

Fresco-painting has been hitherto too little applied to the walls of apartments in private buildings to be ranked among the general means of decoration; but if anything approaching success should attend the efforts now making in England, we may fairly expect to find a new field of enterprise opened up, which will not fail to be applied by persons of wealth and taste to the adornment of private dwellings.

Painting Walls in Encaustic.

There is another mode of painting walls, still less generally known in England than even that of fresco, viz., *encaustic*. This name is as imperfect as that of fresco; it implies "burnt-in;" but there has been abundant discussion as to the material, and as to the processes to which the term is applicable. Encaustic is generally understood to be a kind of painting in which *wax* is the principal material, and that the application of heat in some mode or other to this wax constitutes the chief feature in the process.

Whatever be the real mode of proceeding, it is certain that the moderns derive the name of encaustic from the Romans, by whom this mode of painting was adopted in the decoration of the walls of apartments. The German critics have had a good deal of controversy as to certain descriptions which Pliny gave of the encaustic process. According to the general opinion, there were three styles of conducting this art in practice among the Romans. In the first kind the wax was melted, mixed with some fine earthy colour, as much as it would imbibe, and then spread on a surface of wood or on a wall by means of a heated spatula; when it became cold, it formed the groundwork on which the designer cut the lines of his picture with a cold pointed tool, so that in fact the only part of the picture in which heat was employed was the ground or prepared tablet. The second mode consisted in the application of the former one to small tablets of ivory; these tablets were covered with red or black wax, and the design was cut in this surface with a sharp point, the clear and beautiful surface of the ivory being laid bare in the engraved or etched parts. The third mode of proceeding consisted in the application of the wax-colours by means of a pencil; the wax was dissolved, the colours mixed in it, and the two together were laid on with a pencil, the painting being afterwards finished by holding a hot iron near the surface, as a means of slightly melting the wax; this was in fact the only one of the three to which the name of encaustic could properly be applied, since the others did not require heat in the process of painting. When the process became a little further advanced, a fourth method was adopted, comprising some of the features of the first and third. A wax ground was first laid on, and the design was traced on this with a style or point; each colour to be used in the picture was ground up into the form of sticks or cylinders, and from each he separated, by melting with a hot instrument, enough of the coloured wax to cover a certain space; this he spread over the picture, and then proceeded to other colours in a similar way, finally blending all the colours together with a heated iron or style.

The art appears to have been completely lost sight of, from the time of the ancients till about a century ago, when Count Caylus and M. Bachelier, independently of each other, turned their attention to the matter. Caylus conducted a course of experiments on the subject, and he presented a memoir to the Academy of Painting at Paris, in relation to the probable mode adopted by the ancients in encaustic painting. In 1754 he presented to the Academy a head of Minerva painted in this manner. M. Bachelier, however, had produced a similar picture five years before, and wrote a memoir illustrative of his method. The process by Bachelier was conducted thus:—The tablet on which the picture was to be painted was waxed over, by rubbing it with a piece of bees'-wax; it was then held before a fire, or otherwise heated, to such a degree as sufficed to melt the wax, and to diffuse it equally over the surface. As the water-colours employed would not adhere to the wax itself, a little chalk or Spanish white was applied to the waxed surface, and on this the colours were applied; when the picture was dry, heat was applied to it, sufficient just to melt the wax, and to enable it to absorb the colours.

A great many painters in Germany have within the last few years directed their attention to encaustic painting, and many different processes have been advanced as applicable to the subject. In this country, too, similar attempts have been from time to time recorded. In 1787 a Miss Greenland communicated to the Society of Arts certain details on this subject, which she had gathered at Florence, and also presented to the Society a specimen of encaustic painted by herself. In one of the volumes of the Society's 'Transactions' is given her own account of the mode followed, which is sufficiently minute to convey a tolerably clear notion of the matter:—"Take an ounce of white wax, and the same weight of gum-mastic, powdered. Put the wax in a glazed earthen vessel, over a very slow fire, and when it is quite dissolved, throw in the mastic, a little at a time, stirring the wax continually until the whole quantity of gum is perfectly melted and incorporated; then throw the paste into cold water, and when it is hard take it out of the water, wipe it dry, and beat it in one of Mr. Wedgwood's mortars, observing to pound it first in a linen cloth, to absorb some drops of water that will remain in the paste, and prevent the possibility of reducing it to a powder, which must be so fine as to pass through a thick gauze. It should be powdered in a cold place, and but a little while at a time, as after long beating the friction will in a degree soften the wax and the gum, and instead of their becoming a powder, they will return to a paste. Make strong gum-arabic water, and when you paint take a little of the powder, some colour, and mix them together with the gum-water. Light colours require but a small quantity of the powder, but more of it must be put in proportion to the body and darkness of the colours, and for black there must be almost as much of the powder as colour. Having mixed the colours, and no more than can be used before they get dry, paint with fair water, as is practised in painting with water-colours, a ground on the wood being first painted of some proper colour, prepared in the same manner as is described for the picture: walnut-tree and oak are the sorts of wood commonly made use of in Italy for this purpose. The painting should be very highly finished, otherwise when varnished the tints will not appear united. When the painting is quite dry, with rather a hard brush (passing it one way) varnish it with white wax, which should be put into an earthen vessel, and kept melted over a very slow fire till the picture is varnished, taking care that the wax does not boil. Afterwards hold the picture before the fire, near enough to melt the wax, but not to make it run; and when the varnish is entirely cold and hard, rub it gently with a linen cloth. Should the varnish blister, warm the picture again very slowly, and the bubbles will subside. When the picture is dirty, it need only be washed with cold water."

It will be observed that in most of the above allusions to encaustic painting the specimens are spoken of as being separate and distinct pictures, capable of being removed from place to place like pictures generally. But it seems evident that the Romans adopted some such method as this in decorating the walls of their rooms; and it is in this sense that the subject comes under our notice in this place. An event to which we have lately alluded, viz., the erection of the New Houses of Parliament, has given an impulse to decorative art in more ways than one; for in the inquiries of the Committee and the Commissioners bearing on the subject, encaustic painting as well as fresco came more or less under notice. One result of this new impulse has been the painting in encaustic of the merchants' piazza surrounding the new Royal Exchange, by Mr. Sang, a German artist. A more recent example is that of the new Conservative Club-house in St. James's-street, part of the interior of which is painted in a similar manner.

As to the artistic merits of these new examples of art, criticism has, of course, had full play, and there has been no small diversity of opinion on the matter. But this is not only a probable feature in attempts so novel; it is an advantageous and even a necessary one, for it causes all the various circumstances connected with the matter to be thoroughly canvassed. Let this once become a favourite mode of painting, and we shall not be long in finding it introduced as a decoration for walls, in situations where air and light and temperature are favourable to the development of the method.

Paper-hangings for Wall decoration.

The tapestries, the frescoes, the encaustics, the panelling—however varied and interesting in many respects they may be—all yield to *paper-hanging*, when taken in illustration of the general mode adopted in this country for decorating the walls of a room. It is quite remarkable to see the extent to which this custom is now carried. Throughout the middle ranks of society it is scarcely too much to say that the "sitting-rooms" of the houses are by a very large majority decorated in this way. The kitchens and the upper bed-rooms are less generally papered. Among the higher class of dwellings, painted, gilt, and damask decorations frequently take the place of paper; while those of the humbler class more frequently have the walls of the rooms washed over with a distemper-colouring of white or yellow. At a time, however, when shop-windows exhibit to view (as many walkers through the London streets must have observed) neatly printed wall-paper at such low prices as a penny, a halfpenny, and even a farthing per yard, we ought not to be surprised if the use of this material is greatly extending; thereby carrying decorative art (of however

humble a character) further and further into and among the bulk of inhabitants throughout the country. It is in this case, as in many others, almost impossible to estimate adequately the effect which results from the removal of an Excise duty on a commodity in common use: we can understand that the State loses a certain amount of revenue thereby, and we can readily conceive that the manufacturers feel themselves freed from shackles which greatly impeded the improvement of their art; but it requires a closer observation to weigh sufficiently that which is the most important result of the three, viz., the spread of new habits and usages among the people at large in respect to the neatness, salubrity, and cleanliness of their dwellings, and the creation of a love for the ornamental and tasteful. It may not be easy at first to bring the maxim into fashion, but important results will follow the acceptance of the truth that "it is generally as cheap to make a thing beautiful as ugly."

The decorations of the walls in English houses were, in the early periods of their adoption, a good deal influenced by the fashion of having *wainscoted* or smooth boarded partitions and walls to rooms. It was partly as a means of hiding this wainscoting at parts where ornamental carving could not be conveniently introduced, that tapestried hangings came into use. About the early part of the sixteenth century a custom became prevalent of covering the walls with painted leather, the subjects of the painting being historical or arabesque, relieved with ornamental devices in gold and silver. For two centuries and a half this fashion existed to a greater or less degree. Hangings of silk, of satin, and of velvet have also had their periods of fame. In the old English mansions of past times there were not so many broad plain surfaces on the walls of rooms as there now are, and therefore the production of any definite painted or printed pattern was not of so much importance. The ornamental carvings of the fire-places, the doors, the cornices, the windows, and other parts of the room, occupied so much space that there was neither opportunity nor necessity for any broad ornamental patterns. The rooms of many of these old mansions, such as those sketched in Figs. 734, 735, presented walls and ceilings divided and broken up into compartments singularly different from the (too frequently) bare and cold-looking surfaces of a modern room; in this respect they bore a closer resemblance to the picturesque and decorated appearance of the interior of a Chinese mansion (Fig. 745), described and depicted by Sir G. Staunton.

It was about two centuries ago that paper-hangings first came into use in this country. As the art of preparing them became developed, different varieties were introduced to suit the means and taste of different purchasers. The most costly variety is that in which painting is combined with paper-staining: there are wooden blocks carved representing in relief the *outlines* of the figure or device; an impression is taken from these blocks, and the device is filled in by painting with a pencil. A second mode, forming the commonest and cheapest, consists in having the pattern cut out in a sheet of paper, leather, tin, or copper; this is laid on the paper or on the wall, and a brush, dipped in liquid colour, is passed over the perforated sheet, passing through the holes of the pattern to the surface beneath: this constitutes *stencilling*. The usual mode of proceeding, however, is to have as many blocks as there are colours; to carve upon each block the portion of the device which is to be in one particular colour, and to print with all the blocks successively; for although this art is called "paper-staining," it is really one variety of "colour-printing."

The paper is printed in lengths of twelve yards each, one of which is called a "piece." Before paper-making reached its present advanced state, sheets of paper were pasted at the edges to produce the required length; but now, when paper can be made in sheets whose length is measured by miles instead of yards, this troublesome part of the operation may be dispensed with. The "piece" of paper is laid out flat on a long bench, and is brushed over with a liquid ground-colour made of whiting and some one of the mineral colours liquefied with melted size. When this preparatory coating is dry, the printing proceeds. Let it be supposed that the pattern of the paper is to comprise four colours besides the ground-colour: in this case four blocks are carved, each one having at its surface in relief all the parts which are to be of one particular colour, and being cut away at every other part of the surface. The arrangement is such that each colour shall be kept distinct from the other colours during the process of printing—a principle analogous to that which we shall shortly have to explain in reference to floor-cloth printing. The blocks being ready, four vessels of colour are prepared, consisting of the usual mineral colours mixed up in a warm state with melted size. There is a wooden frame covered with leather or flannel, and on the surface so produced a layer of wet colour is laid on by means of a brush. The workman then takes up one of the blocks, places it face downwards on the wet colour, takes up a portion on the whole of the raised or "relief" parts, and transfers this to the paper; he next takes up a second portion, and prints this on a part of the paper close to the former, taking care to make the two impressions join exactly to produce the device—a point in which he is guided by small brass pins inserted in the four corners of the block. When the whole length of the paper has been thus printed with one colour, another block and another kind of colour are taken, and the whole length is printed over again. So likewise a third time and a fourth, and in some elaborate patterns there are as many as eight colours, requiring eight blocks, eight vessels of colour, and eight repetitions of the printing process.

Many varieties of paper-hanging are made differing in some of the details from that here noticed, such as "satin" papers, "flock" papers, "striped" papers, "blended" papers, "gold" papers, "washable" papers. The first of these, deriving its name from a resemblance or supposed resemblance which it bears to satin, is produced by laying a coating of satin-white on the paper, rubbing it with powdered French chalk by means of a brush until a gloss is produced, and then printing in the usual manner; sometimes the paper receives an addition to its beauty by being passed between two slightly heated rollers, one of which has an engraved pattern in imitation of watered or figured silk. "Flock" papers are a very singular variety, since a portion of the pattern is composed of what may be deemed woollen-cloth, and presents that appearance. Pieces of woollen-cloth are, by means of a machine, cut up into minute fragments, forming a kind of down called "flock," which flock is dyed with any required colour. When the length of paper is properly covered with a ground-colour, a block is used to print the device or pattern upon it; but this device, instead of being printed in colours, is printed with an adhesive kind of gold-size or japan, and the flock being sprinkled over this wetted surface, adheres in a fine layer to all the parts which have been printed, all the loose flock being afterwards brushed off. Sometimes flock of two or three different colours is used, in which case there are two or three blocks, the first printing and coating with flock being allowed to become perfectly dry before the next is proceeded with.

A kind of "striped" paper is produced sometimes in a remarkable manner, bearing some such relation to the others as cylinder-printing does to press-printing in typography. The colour is contained in a trough having parallel slits along the bottom; and the paper, passing along in close contact with this bottom by means of a cylinder machine, receives stripes of colour from the continuous flow through the slits in the metal of the trough. Sometimes paper is made to receive a "blended" or shaded ground by the following means: there are several different shades of one colour deposited in a number of cells laid side by side; these tints are all taken up at once by means of a long brush, transferred from them to a cylinder, from thence to a revolving brush, and from thence to the paper, where it produces a series of narrow stripes so gradually blended into each other as to appear like a shaded ground; and on this ground any required pattern may be printed in the usual way. "Washable" paper-hangings, whose distinctive merit is supposed to be indicated by the name, are prepared by mixing the colours with varnish or with oil instead of with size, to enable them to bear washing without injuring the colours. "Gold" or "bronze" papers, or such as present gold or bronze in any parts of the pattern, are prepared by having a part of the device printed with japan gold-size, on which, while wet, bronze powder is lightly rubbed, the other part of the surface of the paper being printed with colours in the usual way.

Patterns of Paper-hangings.

There has, perhaps, been scarcely any other material for the internal decoration and furnishing of a room so varied in the devices borne by it as paper-hangings. At one period in the history of their use no patterns were countenanced but such as exhibited imitations of sculpture and bassi-rilievi, with various shades of grey as the predominating colour. At another time, historical pictures, or others in which history and mythology were mixed up in a certain fashion, were the prevailing subjects. At a different period, again, satin-papers, or such as would imitate the gloss and graceful folds of satin, were manufactured largely. Then, again, as satin-papers were intended to imitate one kind of woven material, so were flock-papers devised to imitate another: the lightness of the one fitted them for the drawing-room, the solidity and richness of the other were deemed more suitable for the dining-room. The architectural style has also been presented in large variety and under many combinations of circumstances. Grecian temples, Gothic chapels, Italian palaces, Chinese pagodas—all have formed, under one or other of the successively prevailing fashions, subjects for paper-hangings.

Generally speaking, however, the patterns of paper-hangings have been very indefinite in character, being formed of coloured spots, waves, scrolls, and other forms to which the designers would probably have been puzzled to give a name. In other cases there is a more clearly defined imitation of the Grecian scroll, arabesque ornaments, or others belonging to some one definite class. Copies of trees, of flowers, of birds, and other natural objects, grouped more or less tastefully with accessories naturally belonging to them, form another class of subjects, which has, however, not yet been very extensively introduced on paper-hangings.

The late lamented Mr. Loudon, whose untiring activity of mind led him to place in a practical form the vast amount of knowledge which he had acquired, took up the subject of paper-hangings in connexion with the arts relating to the building of villas, cottages, and farm-houses. He says:—"An instructive 'natural history' paper for cottages, and the walls of nurseries and school-rooms, a contributor suggests, might be formed by printing figures of all the commoner and more important plants and animals, with the scientific and popular names beneath them; each plant or animal being surrounded by lines, so as to appear either in frames, or as if painted on the ends of stones or bricks. The advantage of the framed lines would be to give unity to the paper as a whole, and also to admit of repairs by taking out any single frame or stone, and replacing it by another. There is no reason, but the expense, why a geographical paper should not be formed; or one exhibiting all the principal rivers, mountains, and cities in the world; or the portraits of eminent men, with their names; or perpetual almanacs; or lists of weights and measures; or chronological or arithmetical tables; or, in short, any useful and instructive subject, which it would be beneficial to the cottager to have frequently before his eyes."

It has been suggested by another writer, that a modified form of this proposal, but of more universal application, would be to have a paper printed with patterns of medallion and picture-frames, into which prints, maps, models, and diagrams might be introduced at discretion. The subjects which filled up these medallions might, in a drawing-room, be the work of a lady's own hand, executed in one or other of the several kinds of painting; or, in an humbler room, they might be filled with coloured subjects published at a cheap rate, but which, at the present day, need not be either vulgar or incorrect merely because they are cheap; or, in a school-room, the subjects chosen might be some among the numerous ones alluded to by Mr. Loudon, either printed, or painted, or written, according to circumstances.

A suggestion was made by a writer in the 'Penny Magazine' (No. 504), bearing pointedly on this matter. He alludes to a custom prevalent in Eastern countries of ornamenting the walls and doors of apartments with moral maxims and sentences from the Koran and other books deemed sacred in those countries. In Turkey and Egypt the walls of the living-rooms, and even of the shops, are so decked; and even the street doors in Cairo, as in Fig. 742, have similar inscriptions in Arabic. The Chinese, too, have selected sentences painted on long tablets, richly gilt and ornamented, and hung on the walls similarly to our picture-frames

The writer above referred to remarks:—"That a custom so generally prevalent in the East (whence we have imported so much of comfort and luxury, and so much of poetry and romance) should never have been adopted in England appears a mystery. We cannot think that an elegant design on the walls of an apartment can lose anything of its beauty by conveying to the spectator some ennobling thought or virtuous admonition, couched in the language of Shakspere or Milton; nor can we conceive in what way the wisdom of the learned, or even the precepts of religion, could be depreciated either in value or effect by such a method of communication. We believe we shall not be left solitary in our opinion, that a concise sentence accidentally impressed on the mind will often produce more effect, by starting a train of reflections ultimately leading to a good end, than pages upon pages of dispersed matter intended to produce the same result. An idle humour or the unprincipled thoughts of a vacant hour might be checked by such a hand-writing on the wall; while the advice of a Franklin or the satire of a Pope might serve to fix some wavering resolution or turn aside some vicious pursuit."

The manner in which this object is proposed to be carried out may be illustrated by Fig. 736. This is a suggested pattern for paper-hangings, in which the ornamental devices are so arranged as to leave vacant spaces at intervals, having the appearance of tablets. On these tablets verses or maxims are proposed to be introduced, such as those in the cut; of which the lowest is an extract from Montesquieu, implying, "It requires years of repentance to efface a fault in the eyes of man; but a single tear suffices to God." The sentences or verses might be selected at pleasure. The vertical and horizontal lines of the frame-work in the device are proposed to be printed on paper in the usual manner, and pasted on in strips, leaving vacant spaces or tablets to be afterwards filled up with the inscriptions by hand, or by any other means. There is a wide field for the exercise of taste and judgment; for the matter might be made ridiculous if care were not bestowed both on the selection and the arrangement of the inscriptions: the system requires only to be commenced in earnest, and the best mode of carrying it out would be soon hit upon. The idea is but a

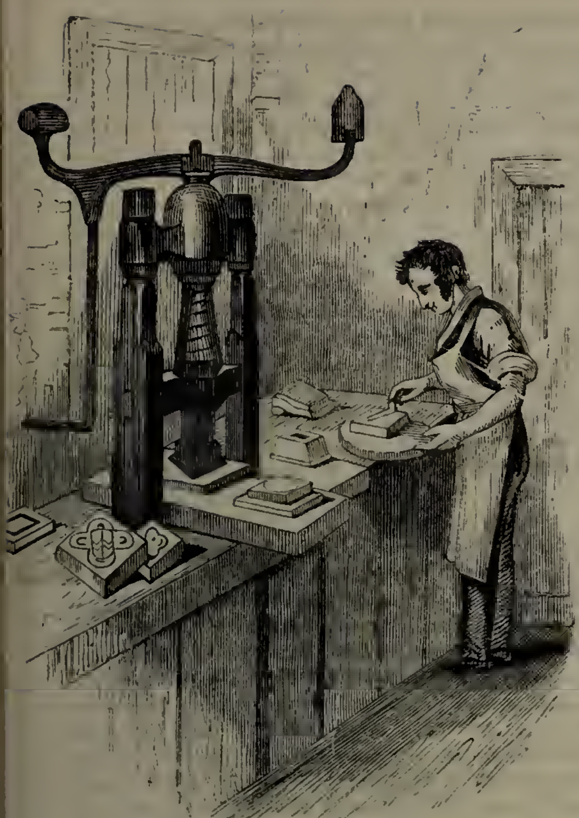
752.—Large Mosaic Picture, forming the Dining-hall Floor of a House at Pompeii.

754.—Mosaic Floor of a House, Pompeii.

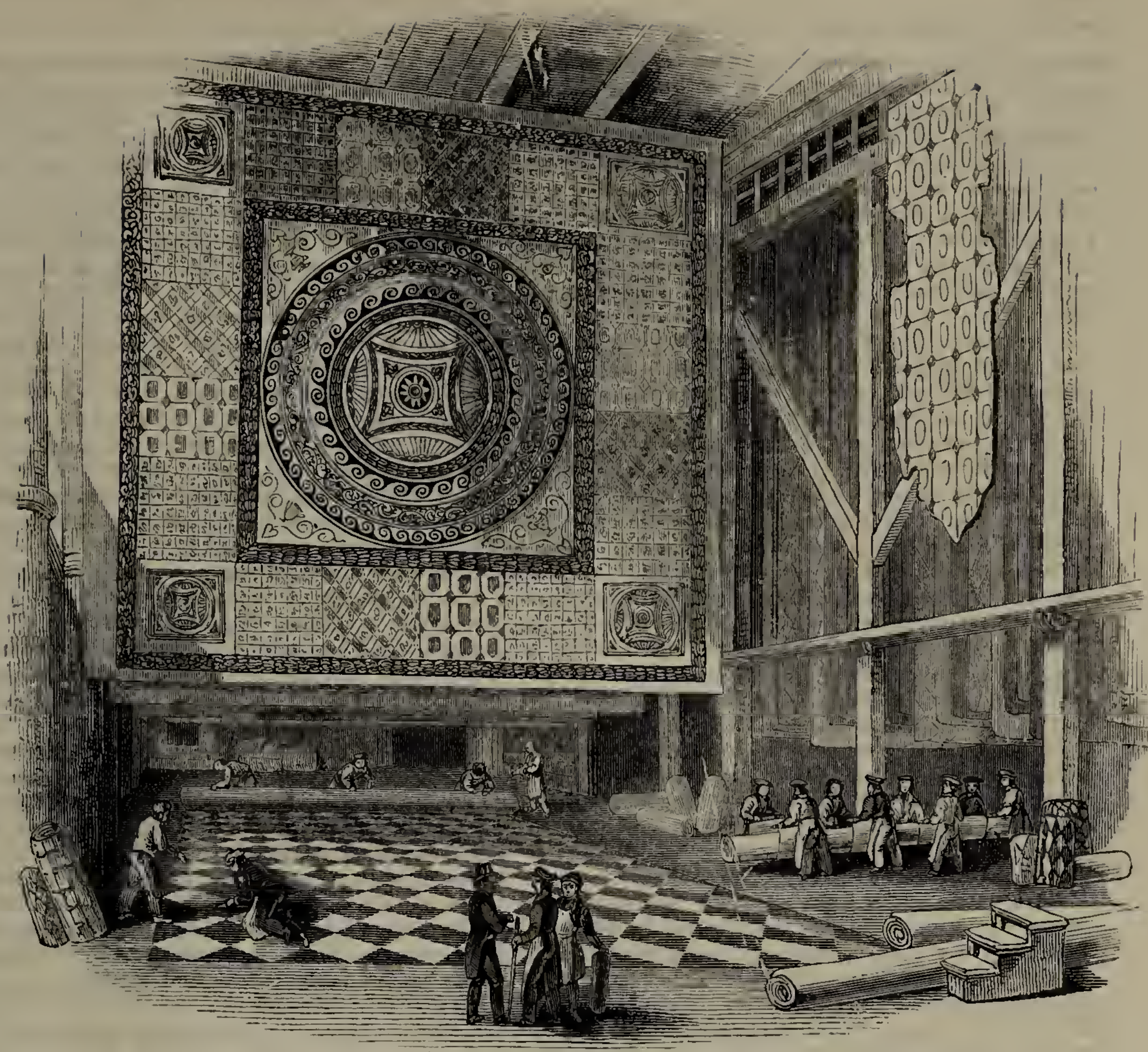
753.—Part of a Mosaic Pavement, Pompeii.

755.—Mosaic Picture, forming the Floor of a House at Pompeii.

756.—Roman Mosaic Pavement, dug up in London, 1803.



757.—Making Tessellated Tiles.

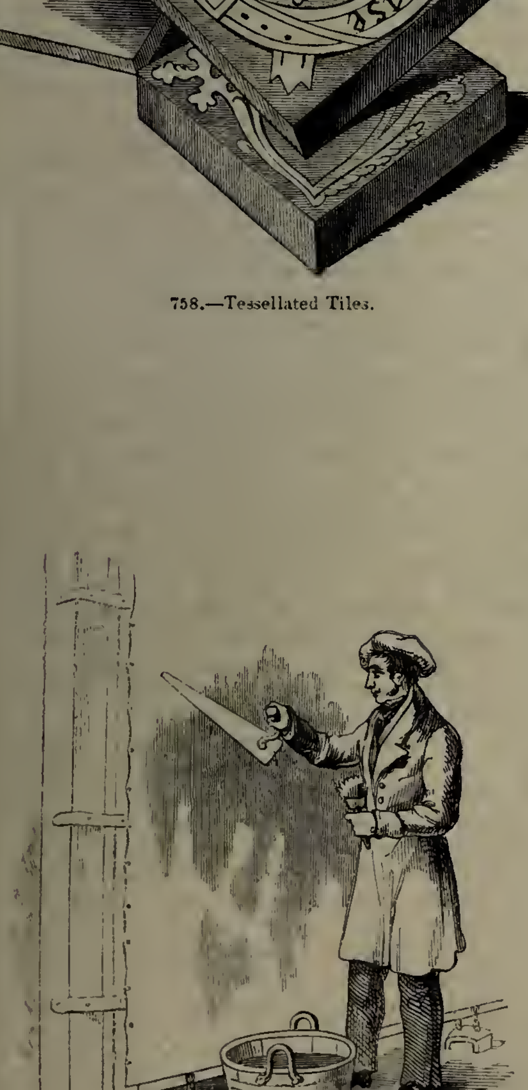


763.—Manufactured Floor Cloth.

758.—Tessellated Tiles.

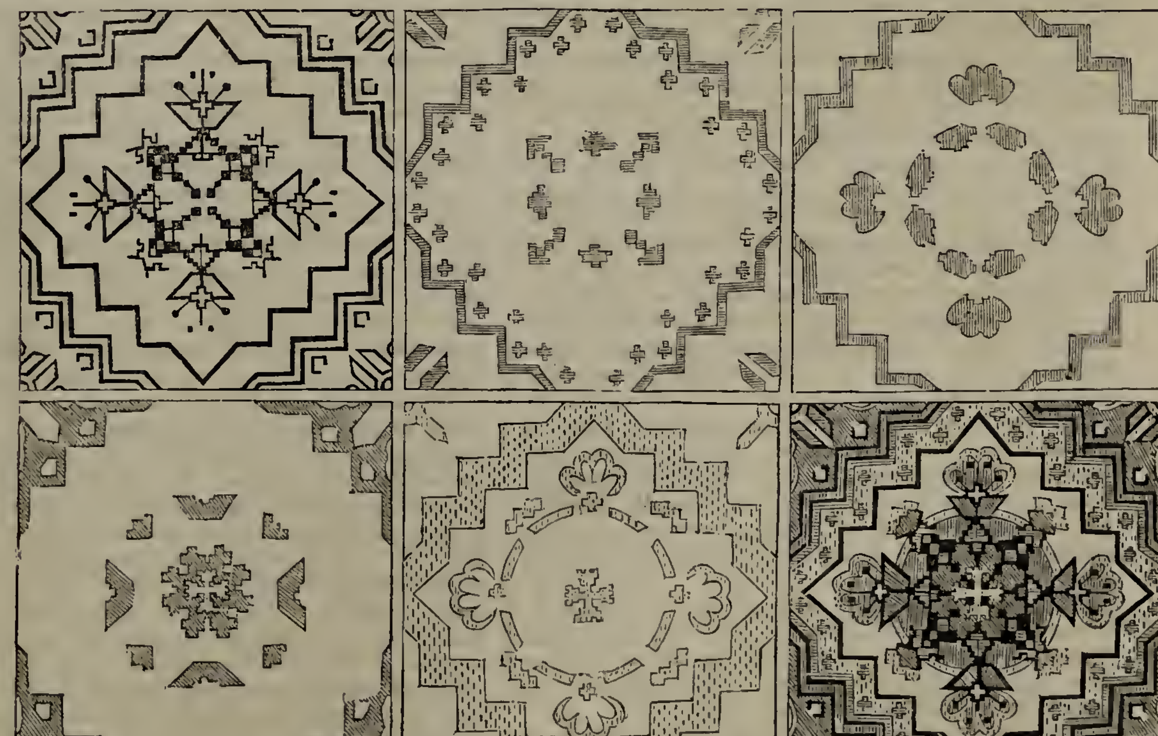
761.—Printing Floor-cloth.

760.—Preparing for printing Floor-cloth.



759.—"Trowel painting" a Floor-cloth.

Black. Blue. Red.



Green. Yellow. Combined Colours.

762.—Component parts of a Floor-cloth pattern.

renewal of one which was put in execution, under a somewhat different form, three centuries ago. There is in the British Museum a volume containing drawings of about forty different tablets, all exhibiting an ornamental frame-work with an inscription within. They once adorned the apartments of Sir Nicholas Bacon; and there is an inscription on one of them to the effect that they were "painted in the Lorde Kepar's gallery at Gorhambury, being selected by him out of divers authors, and sent to the good Ladye Lumley at her desire."

It has been, in past years, a source of great retardation to the progress of paper-staining as an artistic branch of industrial art, that while the duty pressed heavily on the finished article, the copyright in the designs or patterns was so short that the manufacturers could hardly afford to pay clever designers to furnish new patterns so often as they would otherwise have wished to do. It was stated in evidence before a committee of the House of Commons on the copyright of designs, in 1840, that in France the paper of respectable rooms is renewed almost annually, whereas in England one papering is made to last generally from five to ten years: this circumstance arises evidently from the greater expense of the manufactured article in England than in France: but it is also easy to see that this must have a serious effect in cramping the taste and inventive powers of the designers. However, both the duty and the copyright have been placed on a better footing than formerly, and a more extended field of exertion is laid open.

The Mosaic Floors of early times.

Having devoted a little attention to the walls of rooms, let us now glance at the modes in which the decorative arts have been brought into requisition for covering the floors and pavements of buildings, or of forming the pavements themselves. Here, as in other matters, the usages of different ages and of different countries mutually illustrate each other, by showing that in many instances a fashion, after dying away for centuries, revives again into new life.

That variety of pavement or flooring which consists of *mosaic* or *tessellated* work was very extensively employed by the Romans, as is evidenced not only by the pavements of still-existing buildings, but in the excavated ruins of Pompeii. The specimens of this art there brought to light are chiefly composed of black frets, or meandering patterns, on a white ground, or white ones on a black ground. The materials of which they are chiefly composed are small pieces of black and white marble, and red tile, some larger than others, so as to take a deeper hold in the mortar than the rest, and thus form a sort of bonding-course which gave stability to the whole. These pieces were set in a very fine cement, laid upon a deep bed of mortar which served as a base.

Pliny describes very minutely the plan adopted by the Romans in making cement or plaster terraces, which may have been the foundation or groundwork on which the tesseræ or mosaic pieces were laid. "To make a terrace of this sort," he says, "it is necessary to lay two courses of boards, one athwart the other, the ends of which ought to be nailed, that they should not twist nor warp; which done, take two parts of new rubbish, and one of tiles stamped to powder; then with other three parts of old rubbish mix two parts of lime, and herewith lay a bed of a foot thickness, taking care to ram it hard together. Over this must be laid a bed of mortar, six fingers thick, and upon this middle layer large paving-tiles, at least two fingers deep. This sort of pavement is to be made to rise to the centre in the proportion of one inch and a half to ten feet. Being thus laid, it is to be planed and polished diligently with some hard stone; but, above all, regard is to be had that the boarded floor be made of oak. As for such as do start or warp any way, they be thought nought. Moreover, it were better to lay a course of flint or chalk between it and the lime, to the end that the lime may not have so much force to hurt the board underneath it. It were also well to put at the bottom a bed of round pebbles. And here I must not forget another kind of those pavements which are called Græcanica, the manner of which is this:—Upon a floor well beaten with rammers is laid a bed of rubbish, or else broken tile-shards, and then upon it a layer of charcoal, well beaten, and driven close together, with sand and lime and small cinders, well mixed together, to the thickness of half a foot, well levelled; and this has the appearance of an earthen floor; but, if it be polished with a hard smooth stone, the whole pavement will seem all black."

The above description does not apply immediately to mosaic floors as such, but it serves to show that the Romans practised very extensively the art of forming firm and enduring plaster, one of the important requisites in the production of such floors.

The labour bestowed on some of these mosaics must have been immense; for, instead of representing mere checquers of black and white, they form entire pictures, some of which have great beauty of drawing and of colour. The large specimen given in Fig. 752 is copied from the floor of the dining-hall of a house excavated at Pompeii in 1829, called the "House of the Faun." It is regarded as the finest example of mosaic flooring yet met with, since it adopts a high style of historical painting as its subject, and is worked out with great skill and elaboration. When it was first discovered the Italian critics were enraptured with it; the vividness and harmony of the colours, the wonderful transparency of the atmosphere, and the correct drawing of the figures, called forth high encomiums. Professor Quaranta has said of it: "The extreme delicacy of this work in marble far surpasses the celebrated mosaic of Palestrina, as well as that of Hadrian's villa, which have hitherto been considered as the greatest wonders in this kind of work. Besides, what are four doves, some masks, and a few small figures, in comparison with a painting in which are represented twelve horses, a large war-chariot, and twenty-two persons, more than half the natural size, without reckoning those that were on the left side, which is almost wholly destroyed? It is impossible to describe the consummate skill with which so many figures are arranged and grouped in this confined space, or the truth and correctness of the drawing, the distribution of light and shade, the effect of the colours, and scrupulous attention to the minutest accessories. Michael Angelo and Raffaelle might have been proud of the dying horseman; and Alexander's Bucephalus, the horses of the quadriga, the others that lie on the ground wounded, and especially the one rearing and fore-shortened, are drawn with a boldness and truth in their motions and positions which the greatest modern painters, Raffaelle not excepted, might envy." This praise is perhaps injudiciously glowing; but there can be no doubt that this mosaic must be a wonderful specimen of the art. The subject is supposed to represent one of the battles between the Persians and the Greeks. The odd conceits at the bottom seem of a far inferior stamp, and are probably the work of another hand.

Various other very remarkable specimens of mosaic have been from time to time brought to light in different countries. At the end of the last century a mosaic pavement was discovered near Seville, in Spain, at a small depth below the surface of the ground. It was forty feet long by thirty wide, and contained in the centre a representation of the circus-games of the ancients, while on three sides were circular compartments containing figures of the Muses, &c. In the race-course a busy medley of events was depicted, such as a chariot overturned, the charioteer thrown, horses in confusion, and horsemen dismounted; while several spectators are looking on at the sports. In the compartments, besides the representations of the Muses, were centaurs, children in variously coloured tunics, and animals of various kinds. The floor between the different compartments also exhibited various birds, fruits, and flowers, and great diversity of colour was exhibited throughout the whole.

Another specimen, dug up near Lyons, was composed of small cubes of marble, interspersed in some places with pastes of different colours. In this, as in the specimen just alluded to, the whole details of the circus-games were represented; it comprised no fewer than eight chariots, which appeared as if they had started at once, some of which had fallen, and the horses and charioteers fallen. Spectators surrounded the scene, and seemed to regard it with eager interest.

The representation of pictures by means of mosaic for flooring or pavement was not the only variety known to the Romans. That ingenious people also formed patterns of a more or less elegant kind by the arrangement of small cubes of marble, or stone, or plaster previously coloured. The eleven cuts comprised in Figs. 746 to 756, show specimens of both these styles of pattern, all being executed apparently either by the Romans or while the Romans were in power. One of these (Fig. 753) has the inscription "Salve" ("Hail!" or "Welcome!"); and another (Fig. 751) with its dog and its inscription "Cave Canem" ("Beware of the dog"), bears allusion to the custom of keeping a chained dog at the doors of the houses. It is frequently the practice to denominate as "mosaic pictures" those which represent scenes or events, and as "tessellated pavements" those which exhibit simpler designs, generally in two or three colours only. The most beautiful specimen of Roman pavement yet discovered in London is that represented in Fig. 756. It was dug up in the year 1803, in Leadenhall-street, immediately in front of the eastern column of the portico of the East India House. It lay at the depth of only nine feet and a half below the street; a sewer had cut away a considerable portion of it, but the central compartment, about eleven feet square, was nearly perfect. The whole is supposed to have formed the flooring of a room about twenty feet square. "The device occupying the centre was a figure of Bacchus reclining on the back of a tiger, holding his thyrsus erect in his left hand, while a small two-handled drinking-cup hung from his right; a wreath of vine-leaves circling his forehead, a purple and green mantle falling from his right shoulder and gathered round his waist, with a sandal on his extended left foot, the lacing of which reached to the calf of the leg. This design was surrounded by three circular borders, the first exhibiting on a party-coloured field, composed of dark grey, light grey, and red ribands, a serpent with a black back and white belly; the second, a series of white cornucopiæ indented in black; the third and innermost, a succession of concave squares. In two of the angular spaces between this last circle and the circumscribing rectangular border were double-handled drinking-cups; in the other two, delineations of some unknown plant; both figures wrought in dark grey, red, and black, on a white ground. The square border surrounding the whole consisted of two distinct belts, one described as bearing some resemblance to a bandeau of oak in dark and light grey, red, and white, on a black ground; the other exhibiting eight lozenge figures, with ends in the form of hatchets, in black on a white ground, enclosing circles of black, on each of which was the common ornament, a true lover's knot. Beyond this was a margin at least five feet broad, formed of plain red tiles, each an inch square."—*London*, No. xvi.

Many other specimens of Roman pavement have been dug up in the various alterations which London has undergone within the last half-century. Thus in the course of digging the foundation for an extension of the Bank of England, in 1805, a tessellated pavement was found at a depth of about eleven feet below the surface, and is now deposited in the British Museum: its dimensions are only about four feet each way, and it occupied the centre of a floor about eleven feet square. In Cannon Street, in Holborn Hill, in Crutched Friars, in Broad Street, in Fenchurch Street, in Long Lane, in Eastcheap, in Lothbury, in Crosby Square, and in Threadneedle Street, specimens of these pavements have been brought to light; thereby showing that the use of such flooring was very common among the Romans. No longer ago than the year 1841, a specimen was found in the course of pulling down the French Protestant Church in Threadneedle Street, still glowing with wonderfully fresh and vivid colours.

The Modes of producing Mosaic Floors.

The manufacture of all these varieties of inlaid floors or pavements, whether we call them mosaic or tessellated, depends on the arrangement of small coloured pieces in a definite pattern, the shapes being adapted to each other, and the whole brought to a uniform level. The mode of proceeding, however, differs considerably, according as a mosaic picture or a pavement of tessellated tiles be the object in view. We will speak therefore of the former of these two, and then of the latter.

Where a picture rather than a pavement is required, enamel rather than stone is the material employed, as presenting greater facilities for adjustment in a delicate manner. There is first prepared a frame-work or foundation; then a layer of cement into which the mosaic may be imbedded; and lastly the mosaic pieces themselves. The frame-work, formed either of marble or of a volcanic stone called "piperino," is hollowed out to the depth of three or four inches, over the whole surface, except a portion to form a border at the edges. Grooves or channels, about one inch and a half in depth, are cut in the excavated hollow of the marble, somewhat wider at the bottom than the top, as a means of retaining the cement afterwards applied. The subsequent mode of proceeding is described somewhat minutely by Mr. Cadell, who witnessed the operations in Italy a few years ago; and to his account we will have recourse.

The early mosaic-workers used, as a cement in which to imbed the mosaic pieces, a mixture of one part of slaked lime with three parts of pounded marble, made into a paste with water and white of egg. But this paste is considered by the modern artists to harden too quickly, so that it solidifies before the workman has time to insert the pieces. It is therefore superseded by a mixture of one part of slaked lime with three of powdered travertine stone, mixed up with linseed-oil, and stirred and worked every day with a trowel; the mass is at first level on the surface, but afterwards swells up; each day more oil is added, to prevent it from becoming dry and intractable; and the mass, bearing some resemblance to a smooth ointment, is ready for use in a period varying from twenty to thirty days, according to the season of the year.

The next point is the preparation of the enamel pieces to form the mosaic. The materials, consisting of glass mixed with metallic colouring-matter, are heated for eight days in a glasshouse, each colour in a separate vessel. The melted enamel is taken out with an iron spoon, and poured on a polished marble slab placed horizontally, and another flat marble slab is laid upon the surface of the melted enamel, so that the enamel cools into the form of a round cake three-tenths of an inch thick. In order to divide these cakes into smaller pieces, each one is placed on a sharp steel anvil, called a "tagliuolo," which has the edge uppermost, and a stroke of an edged hammer is given on the upper surface of the cake: the enamel is thus divided into long square strips or prisms, which are cut to a length of nearly an inch. For small pictures the enamel, while in a melted state, is drawn into long quadrangular sticks, which are divided across by the anvil and hammer, or by a file. Sometimes these pieces are divided by a saw without teeth, used with emery, and

the pieces are sometimes polished on a lapidary's wheel. Gilt enamel is occasionally used: this is formed by applying gold-leaf to the hot surface of a brown enamel immediately after it is taken from the furnace, the two being made to adhere by a subsequent heating in the furnace. The colours of the pieces of enamels for producing a picture are extraordinarily numerous and varied. There is (or was twenty years ago) a manufactory of mosaic pictures belonging to the Pope at Rome, situated in a large building southward of St. Peter's. In this building the enamels, in the form of sticks about an inch in length, are arranged in a suite of rooms according to their tints; these tints are *seventeen thousand* in number, all arranged in labelled drawers, boxes, and cases, from which they are withdrawn to be used by the artist very much in the same way as a compositor uses type for printing, the colours in the one case being somewhat analogous to the letters in the other.

The frame-work, the cement, and the enamels being thus all prepared, the artist proceeds as follows:—The cement is laid on in small and convenient portions at a time, to the required thickness, and brought very smooth and level at the surface. The artist then, with the picture which he is to copy before him, selects one after another sticks of enamel of the proper colours, and imbeds them in the cement, taking them up and inserting them with forceps, and fixing them into the cement with a small flat wooden mallet, until their surfaces are level. If the effect does not please the artist, he takes them out and re-arranges them. The cement remains sufficiently soft for a fortnight or three weeks, so that the workman takes care to lay on no more cement at once than he can cover with enamel before it hardens. When one part of the picture is thus represented, more cement is laid on, and another part is done in a similar manner until all is enamelled. As there are likely to be minute crevices between the bits of enamels, they are filled up with powdered marble or enamel mixed with wax, which penetrates by having a heated iron passed over it. When the enamel has remained in its position two months, so as to allow the cement to harden, the upper surface is ground down and polished by means of a flat stone and emery—an exceedingly laborious process.

Such is the mode in which the delicate Italian pictures of mosaic enamel are produced, a mode necessarily involving a large expenditure of time and money. At the manufactory at Rome to which allusion has been made above, mosaic-work is conducted on a large scale; the different materials are arranged in numerous apartments, from whence they are removed by the artists as occasion requires. Besides this establishment, there are many artists in Rome occupied in smaller works such as pictures of birds, insects, flowers, and other objects not exceeding two or three inches across; for such small specimens a frame-work or foundation of hardened copper is used instead of one of marble. As an example of the extraordinary minuteness of the work in some of these mosaics, we may state that there is one specimen, a portrait of Pope Paul V., in which the face alone consists of more than a million and a half of fragments, each no larger than a millet seed! and from this size up to two inches square, pieces are employed in various ways. Another celebrated specimen was one which Napoleon ordered to be made when his power was paramount in Italy. It was to be a mosaic copy of the celebrated "Last Supper," by Leonardo da Vinci, and to be of the same size as the original, viz., twenty-four feet by twelve. The artist to whom the task was intrusted was Giacomo Raffaelle, and the men under his direction, eight or ten in number, were engaged for eight years on it. The mosaic cost more than seven thousand pounds, and afterwards came into the possession of the Emperor of Austria.

Such, then, is the mode of producing the delicate specimens of mosaic which are adapted rather for pictures than for floors or pavements. The latter are produced in a rougher way, with less costly materials, and in pieces of larger size. In most cases the separate pieces are called "tiles," and are made of prepared clay, though in other instances pieces of marble or stone are employed. Of the pavement before alluded to, as having been dug up near the East India House in Leadenhall Street, Mr. Fisher remarks:—"In this beautiful specimen of Roman mosaic, the drawing, colouring and shadows are all effected with considerable skill and ingenuity by the use of about twenty separate tints, composed of tessellæ (cubical pieces) of different materials, the major part of which are baked earths; but the more brilliant colours of green and purple, which form the drapery, are glass. These tessellæ are of different sizes and figures, adapted to the situations they occupy in the design. They are placed in rows, either straight or curved, as occasion demanded, each tessella presenting to those around it a flat side: the interstices of mortar being thus very narrow, and the bearing of the pieces against each other uniform, the work in general possessed great strength, and was very probably, when uninjured by damp, nearly as firm to the foot as solid stone. The tessellæ used in forming the ornamented borders were in general somewhat larger than those in the figures, being cubes of half an inch."

The ecclesiastical architecture of the middle ages was one of the means of reviving the use of tessellated pavements; for many specimens of tiles, once used for this purpose, are from time to time discovered in such buildings. A chequered flooring of black and white marble might be deemed a sort of mosaic; but the specimens here alluded to were tiles, each of which had its own pattern, independent of the combined pattern which all might have presented when laid side by side. In the Norman churches it was a frequent custom to lay down such tiles as a flooring for the high altar and before shrines: at first these tiles were irregularly shaped, and were formed of glazed brick or pottery, painted with some Scripture device on the surface; but afterwards the plan was adopted of using carefully squared pieces, so as to produce greater neatness of joint. Wreaths, circles, heraldic ornaments, and various other devices, were painted upon the tiles, together with griffins, spread-eagles, fleur-de-lis, &c. Various animals, such as the fox, the cock, and others, supposed to have had a symbolic meaning, were also adopted.

It was long known to antiquaries that a mosaic pavement existed in the Chapter-House at Westminster, and this was laid open to view a few years ago, when the tiles, each of which bore a particular device, were found to exhibit as brilliant colours as when first laid down, the sizes varying from about six to ten inches square. At Little Marlow Priory, at Lewes Priory, and at Great and Little Malvern, other specimens have been met with. Towards the close of the last century the attention of antiquaries was directed towards a mosaic pavement found at Caen in Normandy, the separate tiles of which were supposed to be emblazoned with the heraldic bearings of the barons who accompanied William of Normandy to England. The pavement is supposed to have belonged to a building forming part of a convent or abbey built by William, and to have covered the floor of a hall measuring a hundred and fifty feet by ninety. The tiles were about five inches square, made of baked earth. Eight rows of the tiles, running from east to west, bore the arms of William's followers, and between these were ornamental compartments of tiles, formed so curiously into a maze or labyrinth, that it is said the windings of the lines forming the figure or device in each compartment extended to a mile in length. Of the state of this pavement at the time of the French Revolution, Dr. Ducarel said, "Notwithstanding these rooms have been used as granaries upwards of four hundred years, neither the damps of the wheat, the turning and shifting of the grain, nor the wooden shoes and spades of the peasants, constantly employed in bringing in and cleansing the wheat, have in the least damaged the floor, or worn off the painting from the tiles. The only injury this floor has received is the taking up some few of the tiles in order to open funnels through the floor for the more ready conveyance of the corn into the rooms beneath."

Tessellated pavements, like stained glass, have recently come again into fashion, in giving to ecclesiastical buildings a richness of decoration which has not been customary during the last few centuries. Many such pavements have been laid down in churches within a recent period, of which one of the most notable specimens is in the Temple Church at London. This pavement was made because, on renovating this ancient and beautiful building, it was found that a tessellated pavement had formerly existed there, which had for ages been buried beneath a pavement of another kind. The following is a description of the new tessellated flooring which has attracted so much the attention of the visitors to the Temple Church within the last two or three years: "The ground is a dark-red or chocolate, but so elaborately covered with the amber or yellowish ornaments as to make the latter the prevailing hue. The patterns form, first, divisions of various breadth (the widest in the centre of the central avenue), extending, side by side, from the entrance-door to the farthest end of the chancel. Within each division there is no alteration of pattern, but the divisions themselves, as compared with each other, present considerable differences. The two most striking are those next to the broad central one, where, as we pace along, we have the lamb on one side of us and the winged horse on the other, the emblems of the two societies ('Middle Temple' and 'Inner Temple') to which the church belongs. The former is founded on the device of St. John; the latter, it is supposed, on the poverty of the Knights Templars at the outset of their career, when two knights rode one horse. Among the other ornaments of the pavement are a profusion of linked-tailed animals in heraldic postures; lions, cocks, and foxes: tigers with something very like mail upon their shoulders; basilisks, and other grotesques. There are also copies of designs of Anglo-Saxon origin, as figures playing musical instruments; and one illustrative of the story of Edward the Confessor, the evangelist John and the ring, a design which at once tells us from whence the materials for the pavement have been borrowed, viz. the Chapter-House, Westminster Abbey. The pavement formed by the tiles is as strong and imperishable as it is beautiful. The tiles are perforated all over with small holes in the under side; consequently, when they are laid in the cement prepared to receive them, and pressed down, the latter rises into these perforations, and hardening there, binds the whole indissolubly together."—*London*, No. 102.

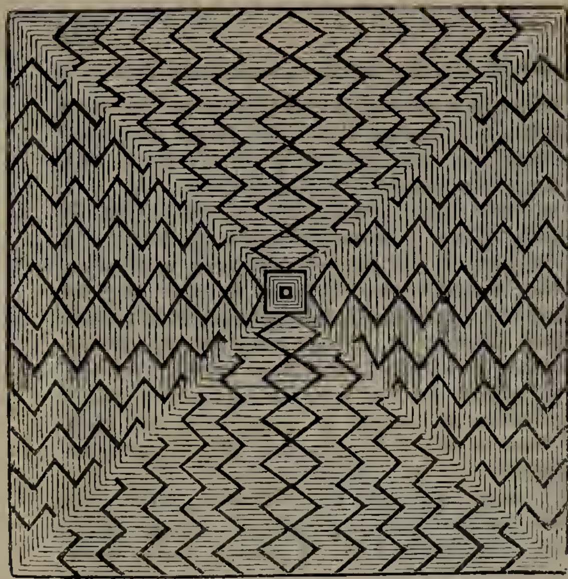
The tessellated tiles of past ages were frequently, if not generally, called "encaustic" tiles, by which we are to understand (if the name be correctly applied) a kind of tile in which the device is in some way or other "burnt in," such being the meaning of the word "encaustic." Now, if the pattern were merely painted on the surface, and then burnt in or vitrified by the action of a furnace, the tiles would scarcely come under the denomination of mosaic or tessellated; and such seems to have been the case in many instances, so far as can be gathered from the descriptions. There was discovered, some years ago, near Malvern, an ancient Roman kiln, in which it is supposed encaustic tiles were baked. It consisted of two parallel arches about thirty-five feet in length, each two feet three inches wide by fifteen inches high. These arches were composed of layers of brick and tile, and had a flooring composed of a less vitrifiable kind of clay than themselves. Below the floor was the fireplace, about fifteen inches in height, and there was a flue at each end of the arches. Near the kiln were found several tiles similar to those in Malvern Church; and from this circumstance the purpose of the kiln itself has been inferred.

Whatever may have been the process followed by the early artists, the tessellated tiles now coming into use for pavements and floors are made by moulding and burning, but without any painting, properly so called. At the large porcelain-works in Staffordshire, Worcester, and elsewhere, this is becoming a regular branch of manufacture, and is conducted (in one of its forms at least) in a manner which we will now briefly describe.

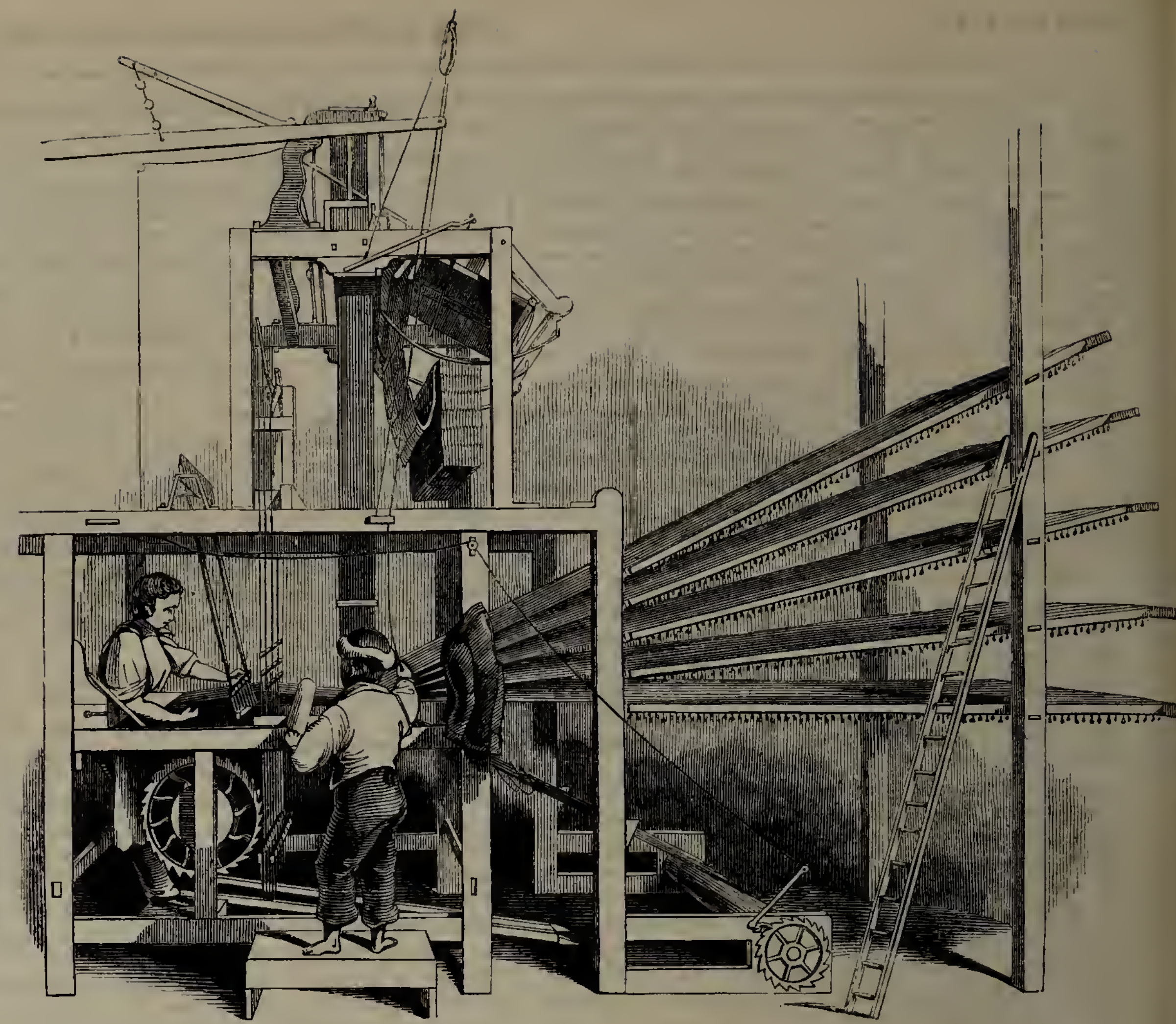
The tessellated tiles are made of two differently coloured clays, one embedded in the other, and disposed so as to form an ornamental device. Three or more colours may be used by somewhat varying the process, but two is the usual number; and whatever may be the colours, the tile is first made entire in one colour, with a depression to be afterwards filled up with clay of one or more other colours. We will suppose the tile to present two colours, a yellow device on a brown ground. In the first place the modeller forms in stiff clay an exact model or representative of one of the tiles, about an inch thick, cutting out to the depth of a quarter of an inch the depression which constitutes the device. When this is properly dried, a mould is made from it in plaster of Paris, and from this mould all the tiles are produced one by one. The ground-colour of the tile is that which is adopted to cast in this mould. This, which we suppose to be brown, is mixed with water to a stiff consistency, and pressed into the mould by the aid of the press (Fig. 757). On leaving the press it presents the form of a damp, heavy, square tile of clay, with an ornamental device formed by a depression below the common level of the surface, as in the original model. The next stage is to fill up this depression with the yellow-coloured clay, so as to bring both colours to a common level. To effect this the yellow clay, so far from being made stiff like the first, has a much more fluid consistency. The tile being laid on a bench, the workman plasters the yellow clay on it by means of a kind of trowel, filling up every part of the depressed device. When this is completed, the tile is allowed to remain six or eight weeks to dry gradually, as a displacement at the joints would occur if the outer surface became quite dry when the interior was yet wet. Each tile is next scraped all over the surface with an edge-tool, till the superfluous portion of the second clay is removed, and the two clays be rendered properly visible, one forming the ground and the other the device. In this state the tiles are put into a kiln or oven, where they are baked in a manner nearly resembling the baking of earthenware or porcelain, the degree and duration of the process having especial reference to the kinds of clay used. Here a point is involved which calls for much attention on the part of the maker. As one of the clays is used in a more fluid state than the other, it would, under most circumstances, contract to a greater degree by heating; but the selection is so made that, notwithstanding the difference of consistency in the two clays, they may contract equally, and leave no unsightly gaps at the joinings. When the tiles are sufficiently baked, they are cooled gradually, and then dipped into a vessel of liquid "glaze," in the same manner as articles of porcelain. After this they are exposed for twenty-four hours to the heat of a "glazing oven," by which the glaze is made to adhere to the surface, and the tiles then appear with whatever ornamental device may have been designedly given to them (Fig. 758).

Parquetry and Composition Flooring.

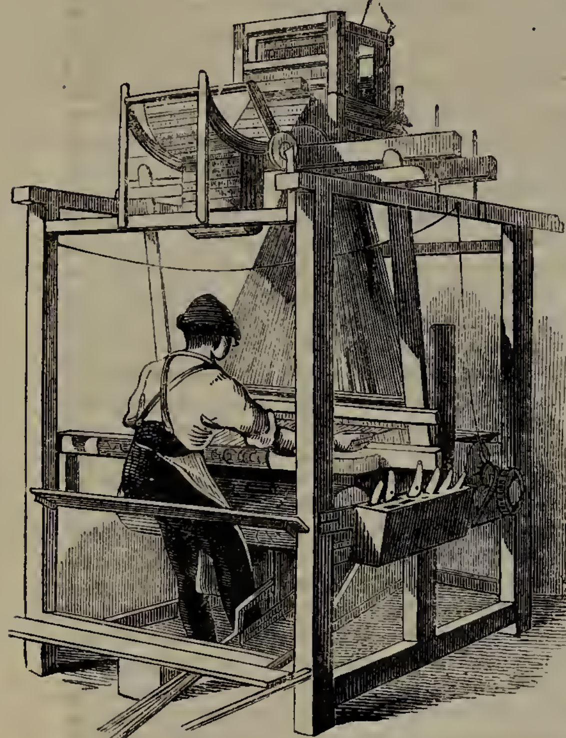
The subject of mosaic or tessellated pavements, which from its variety and the curious matters connected with it has called for rather a full notice, introduces us to one of the modes in which the floors of rooms, as well as the pavements of open courts and areas, may be left with no other covering than that which the builder gave. In modern times, however,



764.—The original Floor-cloth Printing-block.

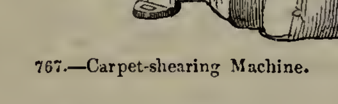


765.—Brussels Carpet-weaving.

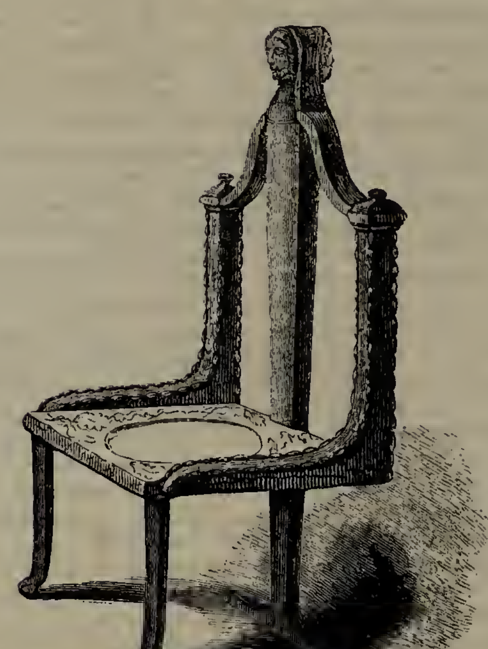


766.—Scotch Carpet-weaving.

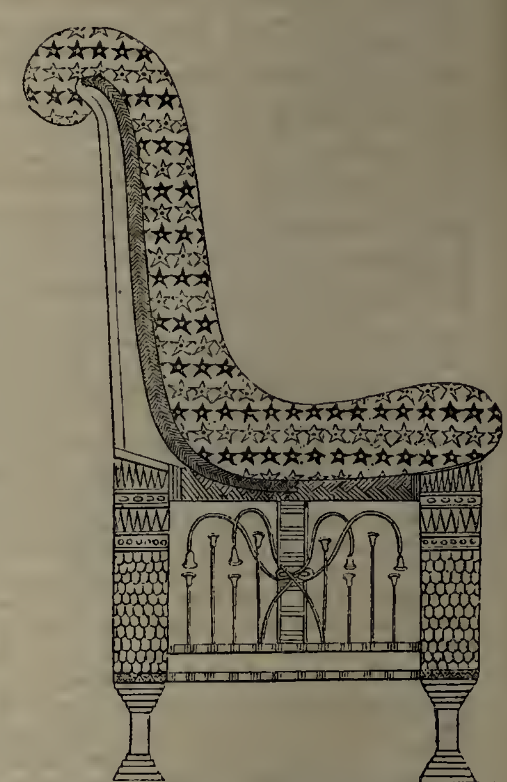
767.—Carpet-shearing Machine.



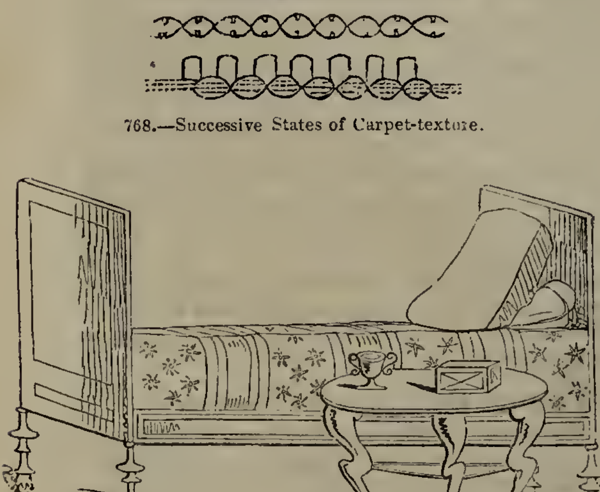
768.—Successive States of Carpet-texture.



770.—Roman Chair.



769.—Ancient Egyptian Chair.



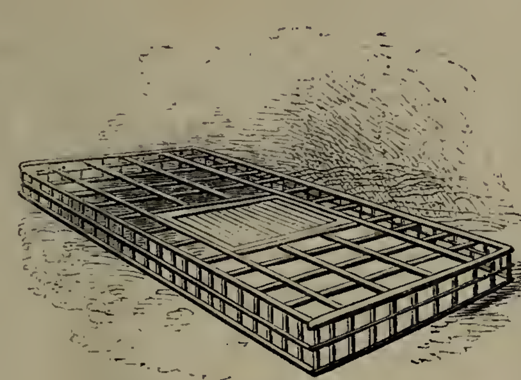
771.—Bed and Table, from Pompeii.

772.—Divan and Door-curtains of a Persian Sitting-room.

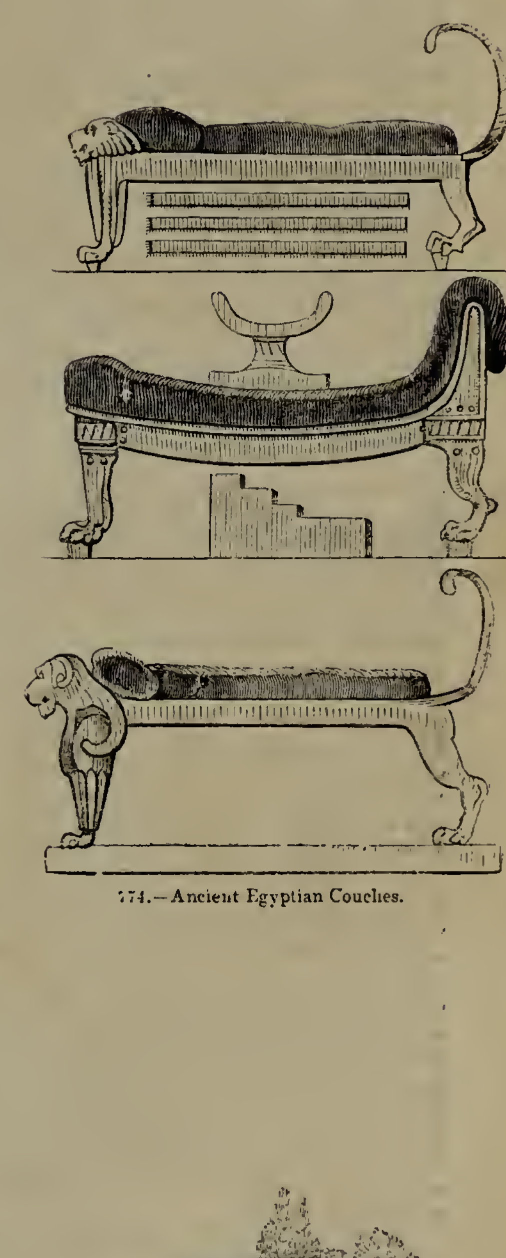
777.—Oriental Divan or Cushion seat.

776.—Eastern Triclinium, or Set of Dining-couches.

775.—Triclinium, Set of Dining-couches, at Pompeii.

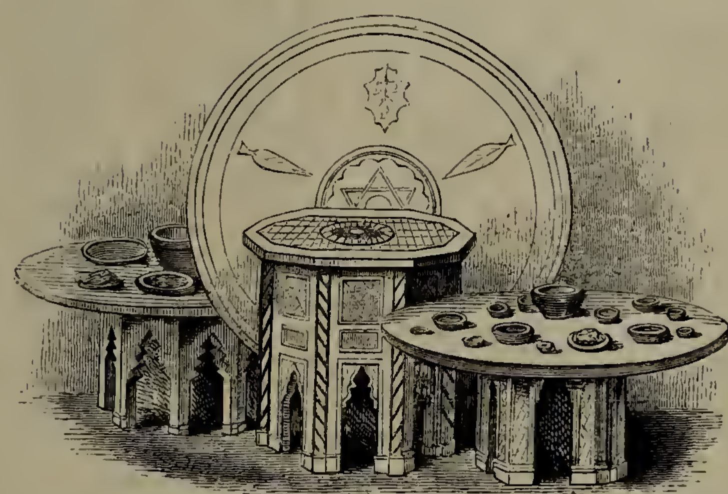


781.—Oriental Palm-Branch Bedstead.



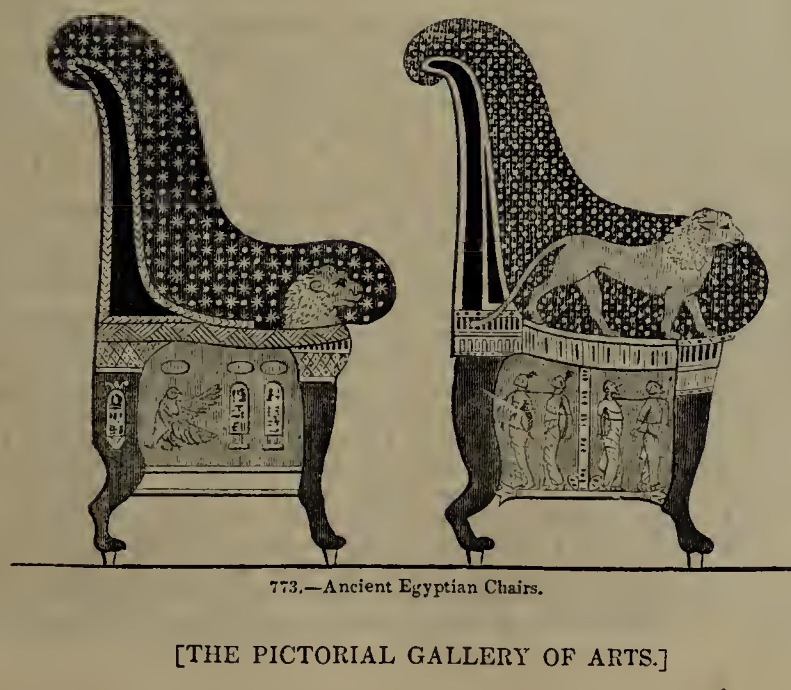
774.—Ancient Egyptian Couches.

779.—Egyptian Stand, and Bed of Table.



778.—Eastern Tables.

782.—Oriental Pillows.



773.—Ancient Egyptian Chairs.

780.—Oriental Garden Bedstead.

floors are very rarely so left; the materials of which they are formed are not sufficiently elegant to remain uncovered, except in a few cases, including the pavements of halls and staircases made of polished marble. Druggets and carpets and floor-cloth are become now of such general use as to render unnecessary those elaborate specimens of workmanship which floors used often to exhibit.

The fine oaken floors of our old English mansions, polished up to a degree of lustre almost rivalling that of a mirror, are often made up of pieces so shaped as to produce an elegant pattern: and they belong to what the French call *parquetry* flooring. They are in fact very commonly adopted in that country; and indeed, being waxed and polished with as much care as the costly articles of furniture, they often present a very beautiful appearance. The introduction of beautifully grained woods from tropical countries raised still further this art, by affording opportunities for the production of splendid effects, which would be unattainable by the use of deal, or even of oak. Some architects or builders have caused rooms to be paved with cheaper and plainer wood through the greater part of the surface, and have had a rich border or fringing of the coloured wood. In other cases, armorial bearings have occupied the centre, and have been similarly bordered with a rich ornamental device. If any of the colours cannot be found in the natural growth of wood (and such is the case), means are found of staining through the entire substance of the wood so as to produce a beautiful colour. The proper colours being selected, the laying down of the floor commences by drawing the intended device or pattern on the whole surface of the under or foundation flooring. This effected, the pieces of wood are cut to the proper sizes and shapes, and fixed down. A foreigner, M. Steinitz, has recently introduced the parquetry system into this country, and is said to have floored two rooms in Windsor Castle by this means; also a small portion on one of the staircases in the New Royal Exchange. His method is described as follows:—The thin pieces of ornamental wood are fitted on stout oak-frames formed into compartments, these compartments forming squares, diamonds, or any other desired shape; the oak frames are rather more than an inch in thickness, and the rich or coloured wood laid on them is from a quarter to three-eighths of an inch in thickness, so as to form a kind of thick veneer. The wood is seasoned by a chemical process which effects the twofold object of preventing warping and shrinkage, and of making it durable. Maple, cedar, mahogany, satin-wood, rosewood, ebony—indeed, all the most beautifully grained woods, if of a character to be slit into thin planks or veneers—are capable of being so employed.

The cutting and shaping of wood for such purposes as these is a delicate branch of art, to which attention was more extensively directed some years ago than at present. When ornamental woods are used for flooring, the term *parquetry* is applied; but the art of forming a kind of wood-work mosaic into ornaments or pictures is known by the French as *marquetry*, and is intimately connected with the former. Some of the early nations practised the art of marquetry; but it was in Italy, in the fifteenth and sixteenth centuries, that it attained great excellence. Before that period, the specimens used were generally black and white, disposed in chequers; but means were discovered of staining the wood, and arranging the pieces so as to form a picture; and a method was also discovered of producing shaded parts in a picture by scorching the surface of the wood without burning it. In the reign of Louis XIV. this kind of work was applied extensively to the decoration of household furniture, particularly to the inlaying of a surface of ebony with little slips of copper. In all such work, the outlines of the thin pieces of wood are cut by means of a very delicate saw. The contour is sketched upon the thin wood, and the saw is made to follow the lines of the device: this is done in one of two different ways; either by fixing the wood in a vice and cutting it with a saw held in the hand, or by the use of a beautiful little machine of modern invention, in which a saw works rapidly in a vertical direction, and cuts through the wood while the latter is lying flat on a bed or tablet.

The floors to which these details concerning ornamental wood-work relate are necessarily of rather a costly kind, and can only be obtained by the higher classes of purchasers. The common deal-boarded floor is, and in all probability will continue to be, the general style among the main bulk of houses in this country. As a means of hiding these unsightly floorings, ingenuity has devised many forms of material, of which *carpeting* and *floor-cloth* are the principal; but there are also two or three other kinds of arrangement occasionally adopted, to which a few lines may be here bestowed.

Mr. Loudon describes a flooring for cottages, made in the following manner:—The ground beneath is covered to the depth of a foot with loose stones; another stratum is laid on, six inches in thickness, composed of gravel and newly slaked lime; this is well beaten and brought to a perfect level; and after it has dried for a week or a fortnight, according to the weather, it is covered to a depth of two inches with a composition of equal parts of quicklime and powdered smithy-ashes, brought to the consistency of mortar by the addition of bullock's blood, stale milk, or oil. As soon as this is laid on, it is well beaten with the back of a spade, or rolled with a cast-iron roller; after which, if rubbed for a considerable time with a piece of coarse woollen cloth, it may be brought to a high polish. Another mode of producing a composition flooring, adapted for a district where Roman cement can be easily procured, is to form a bed or groundwork of this cement, and to insert plain tiles in it; then to coat the tiles over with a mixture composed of one part of cement with two of sharp sand; and, after an interval of a month, to give the floor a second coating of the same mixture, with the addition of as much lime and yellow ochre as will communicate a cream-coloured tinge to the surface. It is said that some of the houses in Bengal are floored in the following manner:—A level surface having been prepared, unglazed earthen-pots, each about a foot in height, are placed close together over the whole surface, with their mouths downwards; the vacant parts round the necks and tops of these pots are afterwards filled up with finely pounded charcoal; and over the whole is laid a flooring composed of well-worked brick-dust and lime, closely compacted: this flooring is considered well adapted for a damp situation.

The flooring itself, whether of mosaic marble, of tiles, of wood, or of composition, is, however, not that surface to which we are accustomed in the respectable class of English rooms. Besides the usual coverings of floor-cloth and of carpet, to which we shall presently more particularly refer, two or three other kinds are occasionally used. Carpets, or rather substitutes for carpets, are sometimes formed in the following curious way:—Pieces of linen, cotton, or canvas, are sewn together so as to produce a square of the proper size; this is stretched out level, and kept down to the floor of a room by pasting it round the edges. Two or three thicknesses of strong paper are pasted on this surface, and over these any fragments or small pieces of paper-hanging, easily procurable at a cheap rate, are pasted in such a way as to produce some sort of pattern, which may easily be done by the exercise of a little taste; the pattern occupying only the centre, or only the border, or being of a more extended character, according to situation. Two or three coatings of thin glue or size are then laid on the paper; after which a coating or two of boiled oil, and then one of copal varnish. The carpet is then finished, and forms a kind of floor-covering differing very considerably from all others to which we are accustomed. Mr. Loudon says: "These carpets are portable, and will roll up with about the same ease as floor-cloth; they are very durable; they are easily cleaned; and, if made of well-chosen patterns, have a very handsome appearance. Where labour is cheap, the cost will be very trifling, the materials being of little value, and the expense consisting chiefly in the time requisite to put them together. Where cloth cannot be easily procured, the carpet may be made by pasting paper to painted boards; when, by repeated coats of paper, it is become strong and firm, it will separate from the paint, and will be as durable as if mounted on any kind of cloth. For earth, brick, or stone floors, in order to render them impervious to damp, these carpets may be made with two faces, by pasting paper to both sides of the cloth which forms their basis, and well oiling or varnishing them on the under as well as upper surface: they may also be bound with leather or any strong substance, to prevent moisture from penetrating to the paste."

Floor-Cloth, and its Manufacture.

The floor-cloth now used rather extensively in English houses is sometimes called "oil-cloth," but it is only such in so far as oil is used in the paint with which it is covered. It is in reality "painted" cloth; or, to come to still greater nicety, it is cloth "printed in oil-colours."

The use of this material, produced by printing with a carved block on a prepared surface, dates back to a period of rather less than a century. It was preceded by the use of cloth, simply painted on the surface to render it more durable. A pattern was probably in some instances imparted to this by the use of stencil-plates, cut open with any desired device, and employed with variously coloured paints. The first attempt to employ a carved block, in the way presently to be described, is said to have resulted in the production shown in Fig. 764; one exhibiting, it must be admitted, no very great degree of elegance or of meaning, but one calculated sufficiently to test the availability of the method. If we compare this pattern with that exhibited in the splendid specimen shown in Fig. 763 (which was copied from a floor-cloth actually made in one of the London factories), we shall see how vast is the difference in respect to complexity of pattern.

Floor-cloth is made of strong woven cloth—not hempen, as might at first be supposed, but of flax. Flax is found to imbibe and retain the coloured paint more firmly than hemp, and is therefore used more largely, though not to the entire exclusion of the other. As it is desirable to have the cloth without seams, if possible, the Scotch manufacturers construct looms expressly for weaving this kind of canvas; and the result is, that single pieces of canvas are brought up to London, and carried through the various manufacturing processes, measuring as much as a hundred yards long by eight wide, all without a seam. One of these enormous pieces forms a bale pretty nearly a yard cube; and as the weight is not much less than five hundred weight, the working arrangements are necessarily of rather a ponderous nature.

The bale is unpacked, and the canvas is stretched out flat on the floor of a large room. A long roller, four or five inches in diameter, is laid down on the canvas, and the canvas is coiled round it, so as to form a thick roll or solid cylinder. This roll is lifted up on its end by a pulley, and is rested by a pivot in a socket, in such a way that the roller can be turned round and round on its axis, and the canvas uncoiled from it. When uncoiled, or while being uncoiled, the canvas is fastened to the beams of a very stout and strong frame, extending the full dimensions of the canvas; and means are afforded for stretching the canvas over the frame to a tightness nearly equal to that of a drum, notwithstanding it presents a surface of eight or nine thousand square feet. In this position the canvas remains several weeks, until it is well painted on both sides. There are several of these frames ranged parallel and vertical, with sufficient room between them for men to stand and work, and stages on which they may stand at any height. The frames vary from a hundred to about a hundred and twenty yards in length, and from six to eight yards in height.

The first process is to level the surface of the canvas, and prepare it for the reception of the paint. It is wetted all over with hot melted size, and rubbed with a flat piece of pumice-stone; by which the little irregularities and knots of the canvas surface are worn down. This is done on both surfaces; and when the canvas is dry, it receives the first coating of oil-paint. This paint is made of pretty nearly the same materials as those employed in house-painting; but it is of so much thicker a consistence, that it cannot be laid on with a brush in the usual way. The workman therefore lays on a mass of the paint in one spot, and spreads it over smoothly by means of a kind of trowel (Fig. 759). When this is dry (which requires a period of several days), the canvas is again rubbed with pumice-stone, then coated a second time in a similar manner to the former, then painted by means of a brush with colour not so thick as before, then rubbed again, and so on; until at length, after a period of nearly three months, the canvas is coated with a smooth and thick layer of paint on both surfaces, so well worked in and upon the fibres as to give the canvas a good deal of the suppleness and toughness of leather.

When the surface is thus duly prepared, the canvas is taken down from the frames, and disposed in such a manner that it may lie horizontally while being printed. There is a large flat bench on which the canvas may be stretched out as it is uncoiled yard by yard from a roller conveniently placed. Here the process of printing goes forward. The printing-blocks, like those employed for paper-hangings, are carved in relief on the surface, the parts left uncut being those which are to form the device. The blocks are about fifteen inches square, and have a handle at the back by which they may be held by the workman. The coloured paint to be employed is spread out thickly by a brush on the surface of a flat padded cushion (Fig. 760); and on this the workman places the block, face downwards, so as to take up a thin layer of paint on every part of the surface forming the device; he next transfers this portion of the device to the prepared canvas (Fig. 761), by pressing the block down upon the surface; and having done so, he makes a second impression in a similar way by the side of the former, taking care that they meet each other at proper points to form the general pattern.

Hitherto all seems simple enough; but when we come to consider the combination of colours in a piece of floor-cloth, the complexity is much greater. There must in this case be as many blocks as there are colours, each one cut differently from all the others, so that there may be a sunken portion wherever any of the others present a raised portion. The preparation of these blocks is thus managed:—A pattern being determined on, it is drawn and painted in full on a sheet of paper the same size as the blocks; every colour and every part of the device being given exactly as it is to ultimately appear. Another piece of paper is placed beneath this pattern, and a pin or pricker is used to transfer one part of the device by following the outlines of one of the colours in the pattern, so as to prick through to the paper underneath. This lower paper is removed, a second one is put in its place, and the outline of a differently coloured portion of the device is transferred in a similar way. A similar thing is done for each colour, there being as many pricked papers as there are colours. This done, each portion of the device is again transferred to the surface of a block prepared to receive it. The block (which is formed of a surface of pear-tree wood glued to a foundation of deal) is laid down face uppermost; the pricked paper is laid

on it; and a little pounded charcoal is dabbed on from a bag, so as to penetrate through the pin-holes, and afford a sufficient guide for the workman in cutting the block. The blocks for one pattern present a very different appearance one from another; since each contains exactly enough raised device for one colour, and no more; and the relative quantities of the various colours depend solely on the pattern. For instance, Fig. 762 gives the component parts of a pattern, sketched from the blocks themselves; the portion at the upper left-hand corner represents the portion of the device which is black, next to this the blue portion, and next to this the red; at the bottom left-hand corner is the green, and next to it the yellow; while the remaining division contains the patterns built up from using all the other five together. The part which each colour fills in producing the total effect may be distinctly traced by comparing the finished pattern with the partial one; since each colour is represented by a particular kind of engraved lines, as in heraldic engraving.

In printing with these several blocks, each one is carried over the whole surface of the canvas, step by step, until the whole of the work is finished so far as regards one colour. Another is then taken, and similarly worked over all the canvas; especial care being observed in making the junctions at the proper places. So likewise with the third, the fourth, and as many colours as there may happen to be. When the canvas is entirely printed, it is allowed to hang up for a long time until dry enough for being walked on without injury.

Carpets, and their Manufacture.

This kind of floor-covering is, in many respects, the most acceptable and approved of all, especially in a country where the climate is scarcely warm enough for many of those which have engaged our attention. Carpet-work is, as every one knows, a species of weaving, modified in its details according to the kind of surface intended to be produced. The kinds known as "Axminster," "Venetian," "Kidderminster," "Scotch," "Brussels," and "Wilton," though not always significative of the places where they are made, indicate several different kinds of woven texture.

Axminster carpets are usually made in one piece, according to the size and shape of the room which they are intended to cover. The warp or "long threads" are of strong linen, and are placed vertically in the loom, unlike the mode of conducting most kinds of weaving. Small tufts or bunches of different coloured worsteds are fastened in and among the warp-threads; and when one row of these tufts has been completed, a weft thread of linen is thrown in by the shuttle in the usual manner. Another row of tufts is then worked in; the colour being so selected as to form a pattern when the whole carpet is completed. The weaver is guided in his proceedings by a design or pattern drawn upon paper, which is fixed up just before him. In fact, the mode of proceeding is nearly the same as that described in a former page respecting Persian rugs, the arrangement of the loom and threads being nearly the same in kind as those seen in Fig. 553, though on a larger scale. The real Turkey carpets (very rare things in this country) are made in a similar manner; so also are a kind of traced rugs occasionally made. The linen threads of the warp and weft, in all these kinds of carpets, are wholly hidden by the tufts afterwards applied.

In weaving "Venetian" carpeting, generally used for stairs, the warp-threads are arranged in stripes of different colours, and the weft is woven in with or amongst them in such a manner that the warp-threads alone are visible at the surface. There are, in fact, two sets of warp-threads, which enclose the weft between them; and as the weft is thus hidden, different materials are employed according to the price at which the carpet is to be sold, woollen, linen, and cotton being all so employed.

In the weaving of "Scotch" carpet (Fig. 766) the pieces are made about a yard in width, and are afterwards sewn together at their edges to form a carpet of the usual shape. This carpeting is formed without the admixture of any linen threads. The warp is of worsted and the weft is of wool, the difference between the two being that wool has shorter and finer fibres than worsted; and the fabric is so constructed as to form a double cloth, having two sets of warp and two of weft, each warp being intersected by both the wefts: it is, in fact, like two pieces of worsted cloth united together, surface to surface, and it might be possible to separate one from the other without destroying the web of either. The weaver, while at work, as in the case of cloth or calico weaving, sits in front of his loom, where he drives the shuttle with one hand, regulates the shuttle-box and the batten with the other, and works the treadles with his feet. The two sets of warp-threads are arranged in two tiers, one above another, and these threads are connected together in various graspings by the aid of the "draw-boy" or of the "jacquard" apparatus, as described in a former page. The arrangement of the shuttles is rather curious: there are from two to twenty shuttles for each pattern, the number being great or small according to the number of colours in the pattern; they are placed in a kind of box at the weaver's right hand, and he takes them out as he wants them. Suppose that the pattern involved the use of three differently coloured weft-threads, red, blue, and white, and these alternated one with another regularly. In such case he throws a red thread with the red shuttle; lays it down and takes up the blue shuttle, with which he throws a thread; lays down this again, and takes up the white shuttle, and so on, keeping his hands uninterruptedly employed, for he has not only to change the shuttles in this manner, but also to drive up each thread of weft after it is thrown. It results from the peculiar way in which this kind of carpeting is made, that the face and the back of the carpet present exactly the same pattern, but with the colours reversed.

Brussels carpeting, as it is usually called, is much more complex in its formation than Scotch, and requires a loom (Fig. 765) of a more intricate construction; and as it forms at the present day the largest and most important department of the carpet-trade in England, much attention is paid to its development and improvement. The three little diagrams forming Fig. 768 will serve to give some idea of the mode in which the textile structure of Brussels carpet is formed. The carpeting is composed of linen and worsted; the former to constitute the ground or back, and the latter to form the surface. The ground has two tiers of linen weft-threads, so as to afford a vacant space to receive the worsted thread; thus, in the uppermost diagram of the cut, we may be supposed to view the piece of cloth edgewise, the little dots being sections of the two tiers of weft-threads, and the curved lines to be two warp-threads, going respectively over and under the others; then, in the next lower diagram, we suppose the worsted to be introduced between the two tiers of weft-threads, and to be bound up with them. These worsted threads are technically called "ends," and the ends are not inserted singly in this way, but ten or more are inserted between each pair of linen threads; by which arrangement substance, firmness, and solidity are given to the mass. By a very remarkable and intricate system of mechanism a little loop is formed at each intersection in the lowest of the three diagrams by lifting up one of the component threads of the end; first one thread and then another being taken up at different parts of the surface to form a definite pattern. These loops are so thickly studded together that they hide the linen foundation beneath. A Brussels carpet presents therefore at the surface nothing but a series of loops, of such a nature, however, that even if they were cut, the carpet would still be a firm and strong material. Indeed, this is actually done in the manufacture of Wilton carpets, which differ from Brussels only in having the loops cut into a surface more or less resembling velvet: it would not be far in error to apply the designation of a "worsted velvet" to a Wilton carpet. Confining ourselves, however, to the Brussels carpet, the succession of movements is pretty much as follows: The loom has at its hinder end a series of frames, five or more in number, filled with bobbins of yarn, the frames being placed at such angles as to allow the yarn from all the bobbins to unwind and form a uniform warp of threads. The weaver, sitting in front of the loom, is provided with a number of brass wires, each rather longer than the width of the carpet to be woven, and these wires enable him to give that ribbed or corded appearance which is so conspicuous a feature in Brussels carpeting. There are usually five colours in these carpets, and the colours are formed wholly by the warp-threads, of which there are two hundred and sixty of each colour in about twenty-seven inches width of carpet. After a shoot or two of linen thread has been thrown in, the weaver introduces a wire under one of the coloured warps and over all the rest, by which a series of loops are formed which present a round and full appearance when the wire is afterwards withdrawn. He thus proceeds, throwing a shoot or two of weft, then beating them well up, then inserting a wire, then throwing more weft, and so on, repeatedly changing the colour of the uppermost warp-threads by mechanism connected with the treadles. At intervals he takes out all the wires which have assisted in forming the ribbed-like surface of the carpet.

Many kinds of carpet require the surface to be shorn after weaving, to produce a delicate nap or pile, and to remove loose or irregular hairs. This shearing is carried on by means of a very ingenious machine, in which a screw whose worm or thread forms a cutting-edge revolves so that this edge shall come in contact with a straight horizontal edge, and thus act like a pair of scissors. The carpet is so adjusted (Fig. 767) as to be drawn between these two edges, by which the surface is sheared all over, the quantity cut off being dependent on the adjustment of the two cutting-edges.

Furniture of Oriental Houses.

When we look around a modern well-furnished room, with its thousand and one articles of taste, of luxury and of utility, we can scarcely fail to recognise in them the result of a very wide circle of industrial art. If we were to follow the manufacturing history of them all, there is scarcely a branch of art but would come in for consideration, so numerous are the ramifications which they present.

Without attempting anything so extensive or vague, we may fittingly conclude this chapter with a few pages of details concerning the general character of the household furniture prevalent at different periods. As a question of production this depends in a notable degree on the resources of each particular country at each particular time, in respect to the raw materials of manufacture: a question which is very apt to be lost sight of in considerations of this subject. Why is it, for example, that no European countries exhibit such numerous and laboured specimens of carving in ivory as are to be met with in many countries of the East? The reason is to be found partly, no doubt, in that tendency to minute and patient works of detail to which the Hindoos and Chinese are more prone than to works of a more comprehensive character; but it is also dependent on the more ready supply of ivory in the country where elephants are found than in other places. To take another instance nearer home: how great has been the change wrought in the general character of English furniture or "cabinet-work" by the discovery or importation of mahogany! Before that period ebony and pear-tree wood were the prevailing materials of chairs, tables, and similar articles of furniture; but now such materials are rarely used, the lighter and more lively variegated mahogany being used instead. The question of which of these is to be regarded as the best or the most elegant is not now under consideration; it is *the* change, whether for good or bad, to which we allude —a change resulting from the commercial relations between a country which has beautiful wood to sell and another which is willing to buy it.

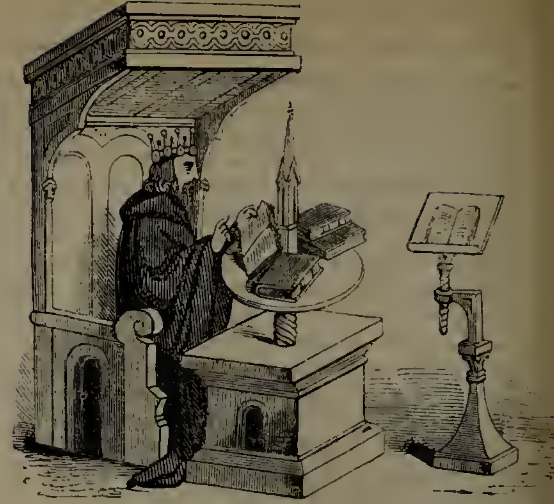
Another point is, as to the forms and general appearance of furniture. Sir Samuel Meyrick, in the introduction to Shaw's splendid work on 'Ancient Furniture,' draws attention to the mutual relation which the architecture of a building and the style of its furniture bear to each other in different ages and countries. He says: "The progress of civilization has constantly a tendency to make articles of convenience become objects of luxury, and hence the ingenuity as well as the taste of man are lavished to render splendid the common necessaries of life. This fact is in no instance more strongly demonstrated than in ornamental household furniture, and any examination of the various successive steps by which the rude block of wood and simple elevated plank have assumed the elegant shapes displayed in modern specimens, is an instructive as well as an amusing pursuit. Although it does not necessarily follow that the forms and ornaments of tables and chairs should, as a fundamental rule, bear reference to the style of a building, yet such an investigation cannot fail to prove that they have been invariably copied from the prevailing architecture of the time. Hence it is that the date of one being ascertained, we arrive at certainty with respect to the other, and hence it is that a similar excellence or debasement in the artistic handling will be found to prevail equally in both. The representations we have of what was used by the Egyptians, the Greeks, and the Romans, are those only of the most finished and tasteful specimens; and, consequently, materials do not exist for the formation of a chronological series. But if we examine such as are of subsequent date in Europe, the reply will be found amply to repay the trouble."

In endeavouring to obtain some little insight into the forms and materials of the furniture of ancient times, we are dependent on different sources, according to the country under consideration. If it be ancient Rome or Greece, the descriptions by the classical writers and the paintings at Pompeii are our chief authorities: if ancient Egypt, the paintings on the walls at Thebes and other places; if in China or India, or Asia generally, the specimens still existing, for the Asiatics are more stationary in their usages than the inhabitants of any other quarter of the globe; if in our own country, the furniture yet existing in the fine old mansions, or the illuminations of manuscripts. Many very large and valuable books of plates have been published on these subjects, drawn from the sources here indicated.

The paintings discovered by Rosellini, Wilkinson, and others on the walls of buildings at Thebes and the surrounding districts, and the relics found in the tombs, show that the furniture of the ancient Egyptians bore a closer resemblance to that of modern Europe than we might at first, perhaps, be apt to imagine. They had handsome chairs, fauteuils, low seats, and stools; some of the chairs were made of ebony and other rare woods, inlaid with ivory and covered with rich stuffs. In chairs of a plainer kind the seat was only from eight to fourteen inches high, sometimes made of wood, and in other instances interlaced with string or leather thongs, not very unlike our own rush-bottomed chairs. Some of the chairs were on the principle of the camp-stool, capable of folding up, and furnished with a cushion or a hide covering; they were sometimes bound with metal plates, or inlaid with ivory; and the leathern covering was frequently fancifully painted. The legs of the chairs were often in imitation of those of some wild animals. Besides the chairs and stools, they had ottomans or small square sofas without backs, raised

784.—Early English Bed. (From ancient MS.)

785.—Early English Bed. (From ancient MS)



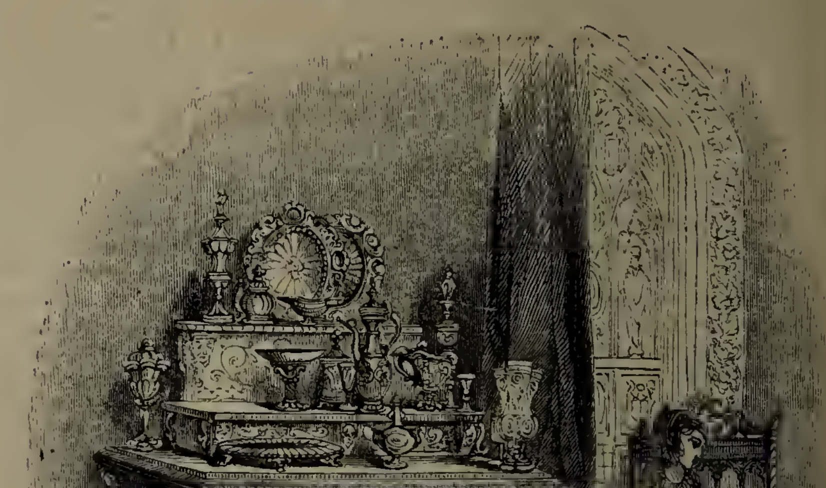
786.—Early English Furniture. (From ancient MS.)

783.—Anglo-Saxon Bed on Wheels. (From ancient MS.)

787.—Early English Chairs. (From ancient MS.)

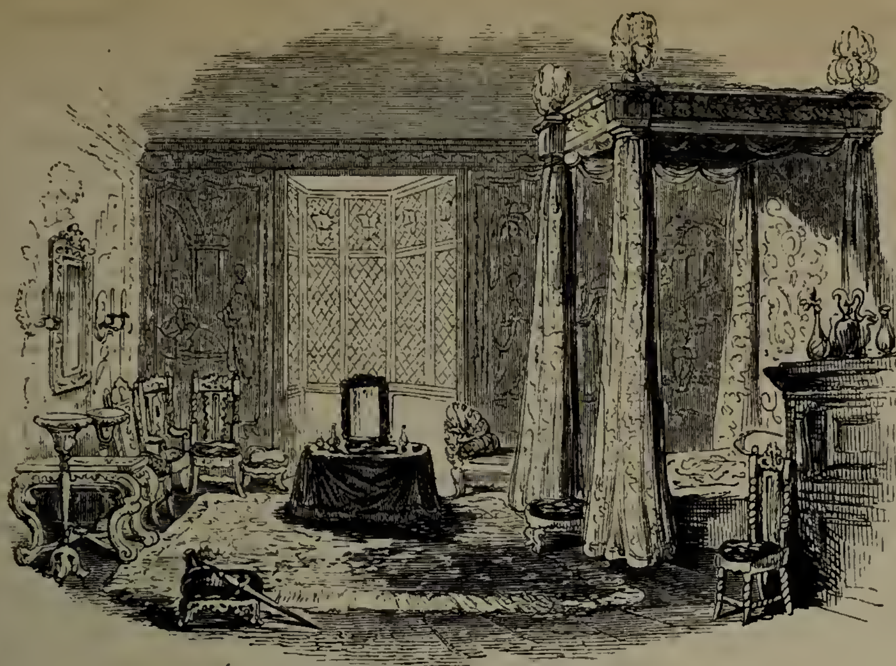
790.—Bedsteads, Shakspere's time.

789.—Chair and Checquered Floor, time of Henry V.



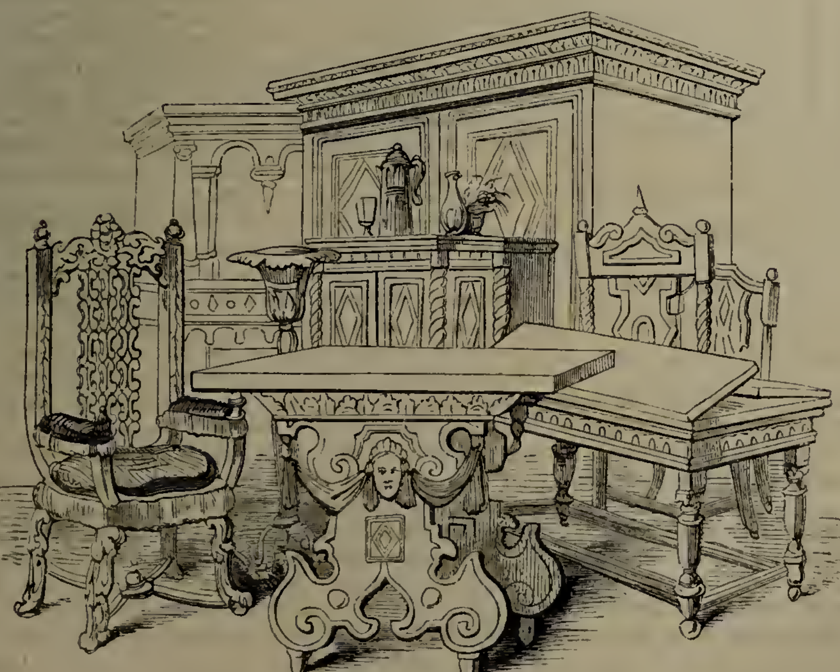
791.—Furniture and Room Ornaments, time of Elizabeth.

788.—Chairs, reign of King John.

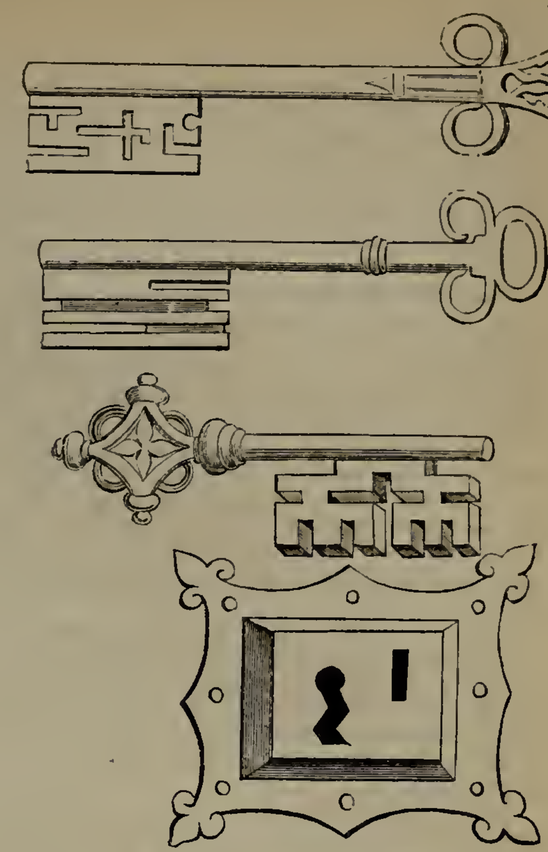


796.—Bed-room Furniture, reign of James I.

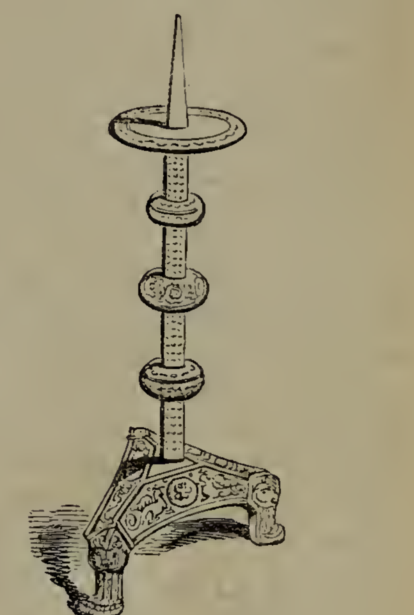
798.—Bed-room Furniture of Louis XIV.



797.—Furniture of the Sixteenth Century.



792.—Keys of Dover Castle.



793.—Chased Silver Candlestick.

794.—Cup found in the Ruins of Glastonbury Abbey.

795.—James I.'s Cradle.

from the ground nearly to the same level as the chairs; the upper part was of leather, or of richly coloured cotton, and the base was of wood ornamented with the figures of captives, who were supposed to be degraded by holding so humiliating a position. Footstools formed part of the furniture of a sitting-room; they were made both solid and open at the sides, and were covered at the top with leather or interlaced string.

The distinction between a bed and a couch does not seem to have been very clearly marked. They had couches of wood with one end raised and receding in a graceful curve, with feet fashioned to resemble those of some wild animal. It is supposed that these couches had a rich covering by day and bedding by night. The use of wooden pillows was customary; they were made of various materials, according to the rank of the possessor, and had a singular kind of cavity in which the head or the back of the neck might rest. Wicker bedsteads were sometimes made of palm-branches, forming a light kind of grating on which the bed and bedding were placed.

The tables used were of various forms—round, square, and oblong. At repasts the dining-table was generally circular, and supported by a central pillar, which was often the figure of a man as a captive. Other tables had three or four legs, and the materials of the tables themselves, though generally wood, was sometimes metal or stone.

It is curious to remark that Egypt exhibited, three or four thousand years ago, articles of furniture bearing a much closer resemblance to those of modern Europe than Egypt does at the present day. The chairs of the early times might in many cases be readily mistaken for those now in use among ourselves; whereas the divans and cushions of modern Egypt, on which the natives indolently recline, belong to the Oriental system of furniture. Mr. Lane tells us that in Cairo no chambers are furnished as bed-rooms. The bed, in the day-time, is rolled up and placed on one side, or in an adjoining closet, which is a sleeping-place in the winter. In summer many persons sleep upon the house-top. The furniture of a room is comprised pretty nearly by the mat or carpet spread upon the floor, and the divans or cushioned couches. For meals a round tray is brought in and placed upon a low stool, and the company sit round it on the ground. There is no fireplace, the room being warmed when necessary by charcoal burning in a chafing-dish.

Passing from Egypt to China, we find, in treating of the furniture of a room, as in many other matters, how singularly isolated the Chinese are from the other nations of Asia, and how much more closely they resemble Europeans. The Chinese are the only Asiatic people who customarily use chairs; they resemble the solid and heavy chairs in fashion during the early part of the last century; the seat of the chair has often a cushion, and the back a hanging of scarlet silk or woollen embroidered with silk. In the forms of their furniture the Chinese generally avoid straight and uniform lines; even in their doorways, instead of a regular right-angled opening, they often have one presenting the form of a circle, or an oval, or a leaf, or a jar. The oval doorway of the beautiful room or pavilion forming part of the "Chinese Exhibition," corresponds very nearly in this respect with one given on a plate by Sir George Staunton. These fanciful doorways, however, are only used when there are no doors, the openings being covered with hanging screens of silk or cloth, or with bamboo blinds, like those used in India. The Chinese beds are generally simple in form, with cotton or silk curtains in the winter, and a fine mosquito-screen during the heat of summer: the bed of an individual among the middle classes usually consists of two or three boards laid upon a couple of narrow benches, a mat to lie upon, and four bamboo-sticks to support the mosquito-curtains. Mr. Davis says: "It may readily be supposed that in the original country of porcelain a very usual ornament of dwellings consists in vases and jars of that material, of which the antiquity is valued above every other quality. This taste has led to the manufacture of factitious antiques, not only in porcelain, but in bronze and other substances—points in which strangers are often very egregiously taken in at Canton. The shapes of their tripods and other ancient vessels, real or imitated, are often fantastical, and not unlike similar vestiges in Europe. In these they place their sticks of incense, composed principally of sandal-wood dust, which serve to perfume their chambers as well as to regale the gods in their temples. The Chinese are great collectors of curiosities of all kinds, and the cabinets of some individuals at Canton are worth examining."

Sitting-room Furniture in Ancient Times.

The Romans, from all the accounts which have been handed down respecting them, seem to have had two very marked epochs in their history, in all that related to luxury of ornament, of furniture, or of dress. Before their chief became an emperor, and while they were fighting their way vigorously against other nations, they were hardy in their habits, inured to fatigue, and often to privation, and heedless about the effeminate luxuries which have at all times been deemed characteristic of more Eastern nations. But when they had conquered so much as to render their empire the most gigantic which the world has yet known, and had gathered wealth from all sources, they lost much of their vigour of character, and declined into the viciously indolent habits of the Asiatics whom they had conquered. The luxuries of their furniture, and household and personal ornaments, as described by some of the early writers, almost exceed belief; gold and silver, and precious stones, ivory and ebony, and pearl—all took part in the decoration of articles which would have been made of plain wood in the more hardy and simple times of the republic.

One of the most curious examples of the importation of Asiatic usages into Rome was in the mode of employing a seat or couch at table. There was in use among them, at Rome, Pompeii, and elsewhere, a curious kind of three-sided couch, the arrangement of which exhibited in a remarkable degree some of the customs of that people at meal-times. The name *triclinium* was applied sometimes to a kind of dining-room, but more frequently to the arrangement of seats in the room: it signifies "three couches" or "three beds," and would be rather incomprehensible to us were we not to bear in mind that the Romans *reclined* rather than *sat* at their meals. It is true that in an earlier period of their history they sat as we do; but during the greater part of the duration of the empire, the Oriental fashion of reclining was in use among them. At first the couches on which they reclined were clumsy in form, and covered with mattresses stuffed with rushes or straw; hair and wool mattresses were introduced from Gaul at a later period, and were soon followed by cushions stuffed with feathers. The couches were at first small, low, and round, and made of wood: but in the time of Augustus others of square and highly decorated forms came into use. In the reign of Tiberius they began to be veneered with costly woods or with tortoiseshell, and were covered with costly embroideries brought from Asia.

The *triclinium* consisted properly of three couches, so arranged as to occupy three sides of a square (Figs. 775, 776), a table, more or less large according to the sumptuousness of the meal, occupying the central place. The guests reclined on the couches, with their heads towards the table, in what would, to us, doubtless be an awkward attitude. Each guest leaned during a great part of the entertainment upon his left elbow, so as to leave the right arm at liberty; and as two or more lay on the same couch, the head of one man was near the breast of the man who lay behind him, and he was therefore said to "lie in the bosom of the other." Among the Romans the usual number of persons occupying each couch was three, so that the three couches of a triclinium afforded accommodation for a party of nine. The couches were elevated above the level of the table; the guests lay flat upon their breasts, and stretched out their right hand towards the table to reach the food; but the meal being ended, they reclined on the left elbow.

As at a modern dinner-table there are certain places rather more distinguished that the others, so among the Romans the three couches, and the three places on each couch, had different degrees of dignity, and occupied a well-understood position with respect to the host and the principal guests. Thus one couch was called the *summus* or highest, another the *medius* or middle, and the third the *imus* or lowest. Again, the three places on each couch were respectively the *summus*, *medius*, and *imus*, or highest, middle, and lowest. The arrangement may be thus represented:—

		MIDDLE COUCH.			
		Lowest place	Middle place	Highest place	
LOWEST COUCH.		6	5	4	HIGHEST COUCH.
	Highest place	7		3	Lowest place
	Middle place	8		2	Middle place
	Lowest place	9		1	Highest place

[Arrangement of a Roman Dining-table.]

At each couch the middle place was generally the most distinguished one, the position 8 being occupied by the host; when, however, the entertainment was given in honour of any particular guest, his place was sometimes at 4.

These couches were provided with bed, pillows, and cushions of various kinds, according to the luxuriance of the general arrangements.

The other principal articles of furniture in the houses of the wealthy Greeks and Romans were in many respects worthy of attention; and we may here give a few notices concerning them, derived from Smith's 'Dictionary of Antiquities' and from Mr. St. John's 'Manners and Customs of the Ancient Greeks and Romans.'

"The moveables in a Grecian house," says Mr. St. John, "were divided into classes after a very characteristic manner. First, as a mark of the national piety, everything used in domestic sacrifices was set apart. The second division, placing women immediately after the gods, comprehended the whole apparatus of female ornaments worn on solemn festivals. Next were classed the sacred robes and military uniforms of the men; then came the hangings, bed-furniture, and ornaments of the harem; afterwards those of the men's apartments. Another division consisted of the shoes, sandals, slippers, &c. of the family, from which we pass to the arms and implements of war, mixed up familiarly in a Greek house with looms, cards, spinning-wheels, and embroidery-frames, just as Homer describes them in the Thalamos of Paris at Troy. Even yet we have not reached the end of our inventory in mere classification. The baking, cooking, washing, and bathing vessels formed a separate class, and so did the breakfast and dinner services, the porcelain, the plate of silver and gold, the mirrors, the candelabra, and all those curious articles made use of in the toilette of the ladies."

Besides this classification of household furniture and utensils, a further subdivision took place, a separation being made of such articles as might be required for daily use from those brought forward only when grand entertainments were given. The depositing of every article in a given place, too, was as much attended to as the classification into kinds. The more ordinary utensils were generally laid up in a spacious store-room, called *tholos*, a circular building detached from the house, and usually terminating in a pointed roof. When a wealthy man first commenced housekeeping, or hired a new set of domestics, he delivered into the care of the proper individuals his kneading-troughs, his kitchen utensils, his cards, looms, spinning-wheels, and so on; and pointing out the places where all these were to be deposited when not in use, committed them to their custody. Of the holiday utensils more account was made; these, being brought forward only on rare occasions, were consigned to the immediate care of the housekeeper, a complete list of everything having first been taken; and it was part of her duty, when she delivered any of these articles to the inferior domestics, to make a note of what she gave out, and arrange for a due return of them.

The tables and chairs used by the Greeks were in great measure dependent for their form and arrangement on the customary mode of sitting or reclining at meals. When the *triclinium* was used (as just described), furniture more resembling beds than chairs was provided for the guests; but when they sat up in the way familiar to modern Europe, the Greeks were very choice in the manufacture of the tables and chairs. In the time of Homer the tables were of variegated wood, finely polished, and having ornamental feet. Opinions have been divided as to whether the tables were circular or of a parallelogram form; but it is not unreasonable to suppose that different forms were used. It became an object of commerce to import from foreign countries the most curious kinds of wood, to be wrought into tables; these were sometimes supported on four legs, sometimes on three, and sometimes on a central pillar of ivory, of silver, or other costly material. Maple tables, with ivory feet, were a favourite luxury at one time; and the more luxurious of the Greeks had their tables inlaid with silver and other choice ornaments. The pedestal-table was said to have been introduced from Asia Minor. The tables were generally small; and it was customary in such case to place the dishes and the various kinds of meat upon it, and to place this opposite to the diner, wherever he might be. If there were more than one guest, there was sometimes a table to each, and sometimes the guests would divide themselves into parties of two or three, each party having a table to themselves. Some passages in the early writers allude to a board of dishes being placed on the table, or on the pedestal or legs of the table; from which it has been inferred that the bed of the table and its supports may have been made separately, and easily adjusted or renewed.

The *chairs* used by the Greeks had much elegance of form to recommend them, and were made of materials more or less costly according to the means of the owner. Although the thrones on which gods are represented as being seated, in gems and bassi-rilievi, might be regarded as something beyond mere household arrangements, yet they are only larger and finer specimens of the same kind of furniture as was customarily provided in the best houses. Mr. St. John says:—"The thrones of the gods represented in works of art, however richly ornamented, are simply arm-chairs with upright backs, an example of which occurs on a cornelian in the Orleans Collection, where Apollo is represented playing on the seven-stringed lyre; this chair has four legs with tigers' feet, a very high upright back, and is ornamented with a sculptured ear and horses. They had no Epicurean notions of their deities, and never presented them to the eye of the public lounging in an easy chair, which would have suggested the idea of infirmity. On the contrary, they are full of force

and energy, and sit erect on their thrones, as ready to succour their worshippers at a moment's warning. In the Homeric age these were richly carved like the divans, adorned with silver studs, and so high that they required a footstool."

Bed-room Furniture in Ancient Times.

The bed-rooms, bedsteads, beds, and bed-furniture of the more luxurious mansions were often sumptuous, and fitted for more indolent habits than we are apt to attribute to the hardy conquerors of the world. But the current ideas on these points refer more particularly to the bold soldiers on the field of battle or the eloquent orators in the forum; and it is only by a deeper search that the homes are laid open to us.

"Bedsteads," says Mr. St. John, "were generally of common wood, such as deal, bottomed sometimes with planks, pierced to admit air, sometimes with ox-hide thongs, which in traversing each other left numerous open spaces between them. Odysseus's bedstead, which the hero was sufficient joiner to manufacture with his own hands, was made of olive-wood, inlaid with silver, gold, and ivory. Sometimes the bed was supported by a sort of netting of strong cord stretched across the bedstead and made fast all round. Later ages witnessed far greater luxury,—bedsteads of solid silver; or ivory, embossed with figures wrought with infinite art and delicacy; or of precious wood, carved, with feet of ivory or amber. Occasionally also they were veneered with Indian tortoiseshell, inlaid with gold. This taste would appear to have flowed from the East, where among the kings of Persia still greater magnificence was witnessed even in very early times."

Bedsteads are represented on some of the ancient gems, bearing a close resemblance in form to our four-post bedsteads, having four pillars terminating in fanciful capitals, a low floating vallance fastened up in festoons, and a roof-shaped tester. Other bedsteads were of more simple character, consisting merely of posts fitted into one another, and resting on four feet, with a board at the head to support a pillow; sometimes there was a foot-board also, so as to give to the whole a good deal of resemblance to the modern "French bedstead;" and sometimes there was no board either at head or foot. Some of the Roman bedsteads were so high that they were reached by means of steps placed at the side. There was also a distinction between sleeping beds and lounging-beds; and the representations of some of the latter closely resemble our modern sofas and couches.

The kinds of beds and mattresses used with these bedsteads became more and more luxurious as the imitation of Oriental effeminacy extended. Dr. Schmitz says that in the heroic ages of Greece the principal parts of a bed were two; the first was a kind of thick woollen cloak, sometimes coloured, which was in bad weather worn by men over their other garments, and was at other times used as a soft seat for a chair, or as a blanket to sleep in; the other was a softer and more costly kind of woollen cloth, used chiefly by persons of rank, and sometimes covered with linen to make them softer and more agreeable. The bedsteads of persons of high rank were covered first with skins, then with these woollen coverlets, and lastly with linen cloth. Poor persons slept on skins or beds of dry herbs spread on the ground; and such simple beds, with the addition of a kind of pillow, were used for many ages. Where a bed was used, the skin or cloth was not placed on bare wood; but the bedstead was provided with girths or strings, to give elasticity, and on this was placed a mattress made of linen, of woollen, or of leather, and stuffed either with wool or with dry weeds. At the head of the bed was placed a round pillow, the first use of which is believed to have been long after the introduction of the beds themselves; this was probably filled with the same material as the bed.

The bed-covers were a sort of blanket or counterpane, to which various names were applied. The most usual kind were generally made of cloth, very thick and woolly either on one or both sides. But when the Greeks became accustomed to the luxuries of the East, every part of the fittings of a bed-room were of a more sumptuous kind. Mr. St. John, after stating that the Peloponnesians lived the most hardily of all the Greeks, the Athenians next, and the inhabitants of the Ægean islands most sensually, quotes a description of a royal bed which certainly comes up to one's ideas of the pampered and luxurious. Over soft mattresses, supported by a silver-footed bedstead, was flung a short-grained Sardian carpet of the most expensive kind. A coverlet of downy texture succeeded; and upon this was placed a costly counterpane of Amorginian purple. Cushions, striped or variegated with the richest purple, supported the sleeper's head, while two soft Dorian pillows of pale silk formed a resting-place for his feet.

The mattresses used for the finest beds were stuffed with wool from the sheep of Miletos, the softest then to be obtained; and there is evidence that the practice of sewing through the mattress and tufting the pack-thread, to prevent the stuffing from working up into heaps, was practised then as now. The coverlets were made not only of the materials before mentioned, but also of the softest wool. The bed-clothes, too, were perfumed for the more effeminate sleepers, and many of these fragrant counterpanes were wrought with figures of birds and other devices. Carthage enjoyed celebrity for its manufacture of carpets and variegated pillows. The carpets here spoken of seem to have been soft pieces of cloth, which, if thrown over a couch or bed, formed a cushion-cloth, if over the sleeper a coverlet, and when rolled up they probably formed bolsters or pillows. The general utility which a piece of woollen cloth possessed among these people gives to Mr. St. John a subject for an analogy with the modern Irish. "A gentleman travelling in Ireland witnessed the ingenuity of that ready-witted people in applying the same thing to various uses. First, he saw the table-cloth, on which he had eaten a good supper, transferred as a sheet to his bed; and next morning his kind hostess, offering her services to put him in the right way, converted the same article into a mantle, which she wrapped about her shoulders."

Among the Lacedæmonians the youth slept in distinct companies in one common room, as in modern hospitals and barracks. The bed-rooms at Pompeii were very small; they were vaulted, and had a little window for privacy, placed near the roof, with a curtain and shutter. The bedsteads were placed along the wall. In beds destined for two persons, the two sides were distinguished by different names; the front or outer side, where the bed was entered, was called the *sponda*, while the inner side, supported by the wall or by a board, was the *pluteus:* women and children occupied the latter or more protected side.

Of the general fittings of the bed-rooms in the better kind of houses, the author of the treatise on the 'Arts and Manufactures of the Greeks and Romans' (Lardner's 'Cyclopædia') says: "The necessary furniture of a bed-room, both among the Greeks and Romans, is stated by Pollux to have been vessels of glass, metal, or earthenware; washhand-basins and ewers for washing the face at getting up; chairs; benches for two; slippers or woollen socks. Chairs are mentioned by Herodotus whereon to lay the clothes; clothes-chests by Theophrastus. A golden Fortune was placed in the bed-rooms of princes; a portrait sometimes hung over the bed, and there were other pictures. Claudian mentions rooms hung round with mirrors; and Horace, though the passage is disputed, is said to have had his bedchamber so furnished. Pollux enumerates at great length the furniture of the *gynæcum* or women's lodgings. These consist of the instruments for weaving and spinning; baskets for the wool; measures; 'smooth stones,' says Rous, 'like our smooth lace-sticks, that they might not weare, which hung at the end of the thread; scales and weights." Indeed, the enumeration becomes almost too minute to follow, comprising combs, a metal mirror with its case, sandal and shoe cases, alabaster-boxes, masks, and numerous others. These, it may be presumed, were for the higher class of females.

In the arrangement of a Greek house of the better kind there was a pretty general plan followed as to the position of the sleeping apartments. In a Greek family the women lived in private apartments allotted to their exclusive use; hence the house was always divided into two distinct portions, the Andronitis and the Gynæconitis, for men and women respectively. In the earliest times, as in the houses referred to by Homer, the women's apartments were in the upper story; but they are believed to have afterwards been on the same level with those of the men, only in a more remote part of the house. Other cases are mentioned which seem to imply that they were side by side, both fronting the street, and each having a separate entrance. The Andronitis consisted generally of an open court, having an altar in the centre for sacrificing to the household gods; a portico ran round all four sides, used for exercise: from these porticoes entrance was gained to the rooms, such as dining-rooms, capable sometimes of containing six or eight *triclinia* or sets of dining-couches, parlours or sitting-rooms, and the sleeping-rooms. The open court of this group of apartments communicated by a door with the Gynæconitis, or women's apartments. The court of these apartments had a portico only round three of its sides, and on the fourth side was a small vestibule which gave entrance to two bed-chambers, one of which was a sort of state or choice bed-room, where vases and other valuable ornaments were deposited.

The arrangements of a Roman house, in respect to these matters, do not appear to have been so complete, the state of social opinion among the Romans not requiring so much Oriental seclusion of females as among the Greeks.

The various woodcuts given from Fig. 769 to Fig. 782 will illustrate a few of the foregoing details concerning the furniture of the Romans and the Egyptians in early times, and the Oriental nations in our own day. In Figs. 769, 773, and 774, are the elaborately decorated chairs of the ancient Egyptians. In Fig. 770 is a Roman chair; in Fig. 771, a bed and table at Pompeii; and in Figs. 775, 776, two representations of the *triclinium*, or couch-chair. In Fig. 777 is the characteristic *divan* or cushion-seat, so generally used in Asiatic countries; and in Fig. 772, a representation of a Persian sitting-room, in which the divan for a seat, and curtained hangings for the door-way, constitute the principal parts of the room furniture. In Figs. 778, 779, we have two forms of modern Egyptian tables, in which the bed of the table is often merely a round tray, placed upon an ornamental stool as a pillar or support. In Fig. 780 there is depicted a sort of garden bedstead occasionally used in the East; while in Fig. 781 is another form of garden bedstead or couch, built up in a very slight manner of palm-branches, for use in a climate where the open air is much more acceptable than a closed room. Lastly, in Fig. 782, we have a representation of the very curious form of pillow adopted in many Oriental countries, exhibiting a recess for the neck, such as an Englishman would probably be some time in becoming accustomed to.

English Furniture before the Sixteenth Century.

Leaving now the countries which are chiefly interesting to us as furnishing means of comparison, we may next take a glance at our own country, of which the past history is connected with the present by many a link, even furnished by a chair or a table. When a visitor walks through the rooms of any of our celebrated old manor-houses or mansions, such as Penshurst, or Knowle, or Burleigh, how forcibly are his thoughts carried back to the times when the rooms were peopled by men whose names now belong to history! The chairs and the tables and the cabinets, the beds and the couches, have in many of these mansions remained almost untouched for centuries, and lie spread out before us like a map of past usages. And when we go back to a period rather too early for monuments of this kind, we find valuable materials for conjecture in the illuminations attached to ancient manuscripts, many of which represent with scrupulous fidelity the forms of furniture in use when the artist lived.

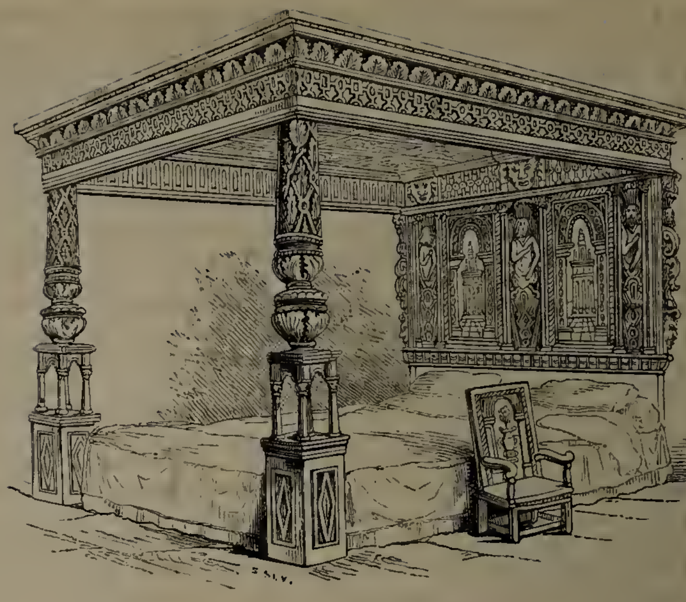
It is a curious and interesting subject to trace the changes which have occurred in the form and materials of the chief articles of household furniture, from time to time in England. The subject is a large one if entered on at all fully; but we may condense (chiefly from the 'Pictorial History of England') a few particulars on the matter.

Among the Anglo-Saxons, the walls of the rooms, in the houses of the wealthy classes, were frequently hung with richly embroidered silk. A common form of chair then used bore some resemblance to the modern camp-stool, consisting of a low seat held in tension by two or more cross-bars. Chairs with backs were, however, also used; and these, as well as the stools, were not unfrequently elaborately carved with the heads and feet of animals and other devices. The tables were made generally of wood; but there are allusions in certain early MSS. to tables formed of gold and silver. In some of the illuminations to these manuscripts, beds and bedsteads are depicted of various forms. In one, the bedstead has a roof like that of a house, and is furnished with curtains and a pillow. Beds, straw-pillows, bed-clothes, curtains, and sheets, are mentioned in wills of the period, showing that such conveniences were well known. Goat-skins and other skins of animals were often used as bed-coverings. In the halls of the larger mansions the tables were moved aside when night came, and beds and bolsters were laid in their places, for the retainers to sleep on.

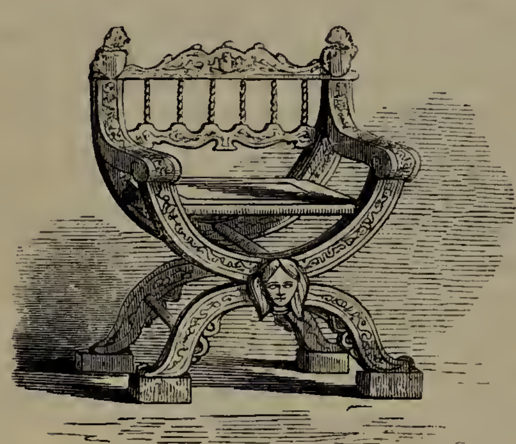
In the earlier years of the Norman race, very few additions or improvements seem to have been made in the domestic furniture of English houses. The manuscript illuminations contain the same kind of tables, of plates, dishes, and cups, of knives and other articles, as were in use among the Anglo-Saxons. The chairs were frequently carved in a very elegant manner. The embroidered hangings, for the best rooms, in fashion at an earlier date, became superseded by the fashion of painting on the walls themselves, or on the wainscot of the chamber; the subject being of an historical or fabulous character. The furnishing of the royal bed-chamber in the reign of King John is illustrated by an entry in the Close Rolls; to the effect that forty-nine shillings and eightpence halfpenny was paid for three pieces of taffety, one and a half of fustian, and five pounds of silk or fine cotton, for three couches or beds for the king, and for the workmanship of the same. Linen was used as a material for sheets at that time. Various articles of furniture, taken from MS. illuminations, are sketched in Figs. 783 to 789.

During the thirteenth and fourteenth centuries the fashion of painting the walls of the best rooms, instead of hanging them with draperies, extended considerably. The subjects of the paintings were generally selected from the Bible, from lays and ballads, or from fables, legends, or romances. In the reign of Henry III. painted-glass windows were sometimes used in domestic dwellings; and in the fourteenth century we read of such windows being made to open and shut. The chairs (of which the "Coronation Chair," in Westminster Abbey, is perhaps the finest now remaining) were often made in conformity with the pointed style of architecture, then recently introduced. The remarkable chair, reading-table, and reading-desk sketched in Fig. 786, are of this period, taken from an old illuminated MS. One of the romances of those times speaks of a bed furnished with a rich quilt wrought

799.—Sitting room Furniture, William and Mary's reign.



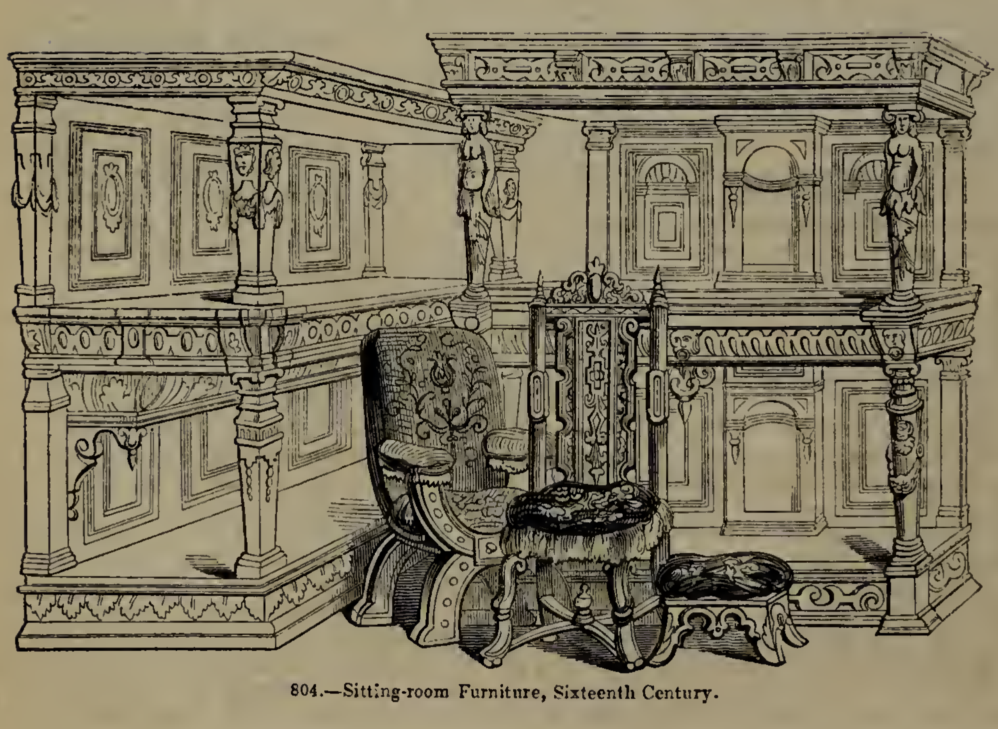
800.—Great Bed of Ware.



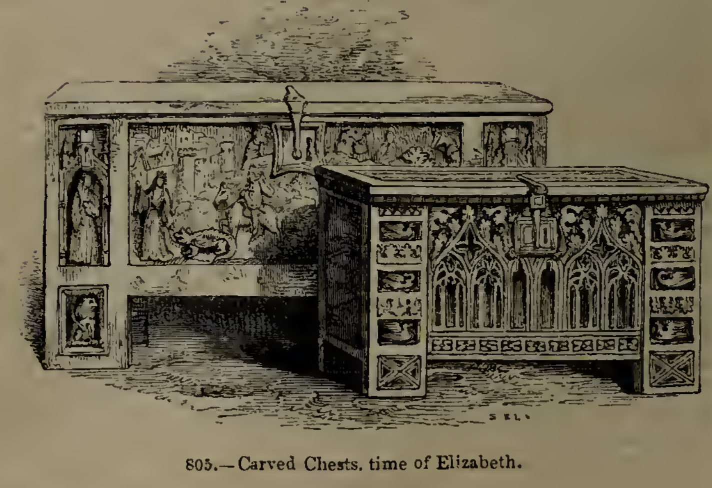
801.—Chair at Moor Park.

802.—Queen Elizabeth's Salt-cellar.

803.—Sitting-room Furniture, reign of Queen Anne.



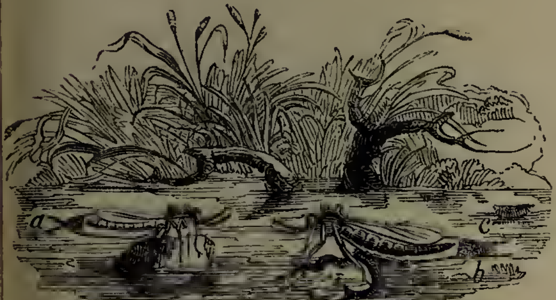
804.—Sitting-room Furniture, Sixteenth Century.



805.—Carved Chests, time of Elizabeth.

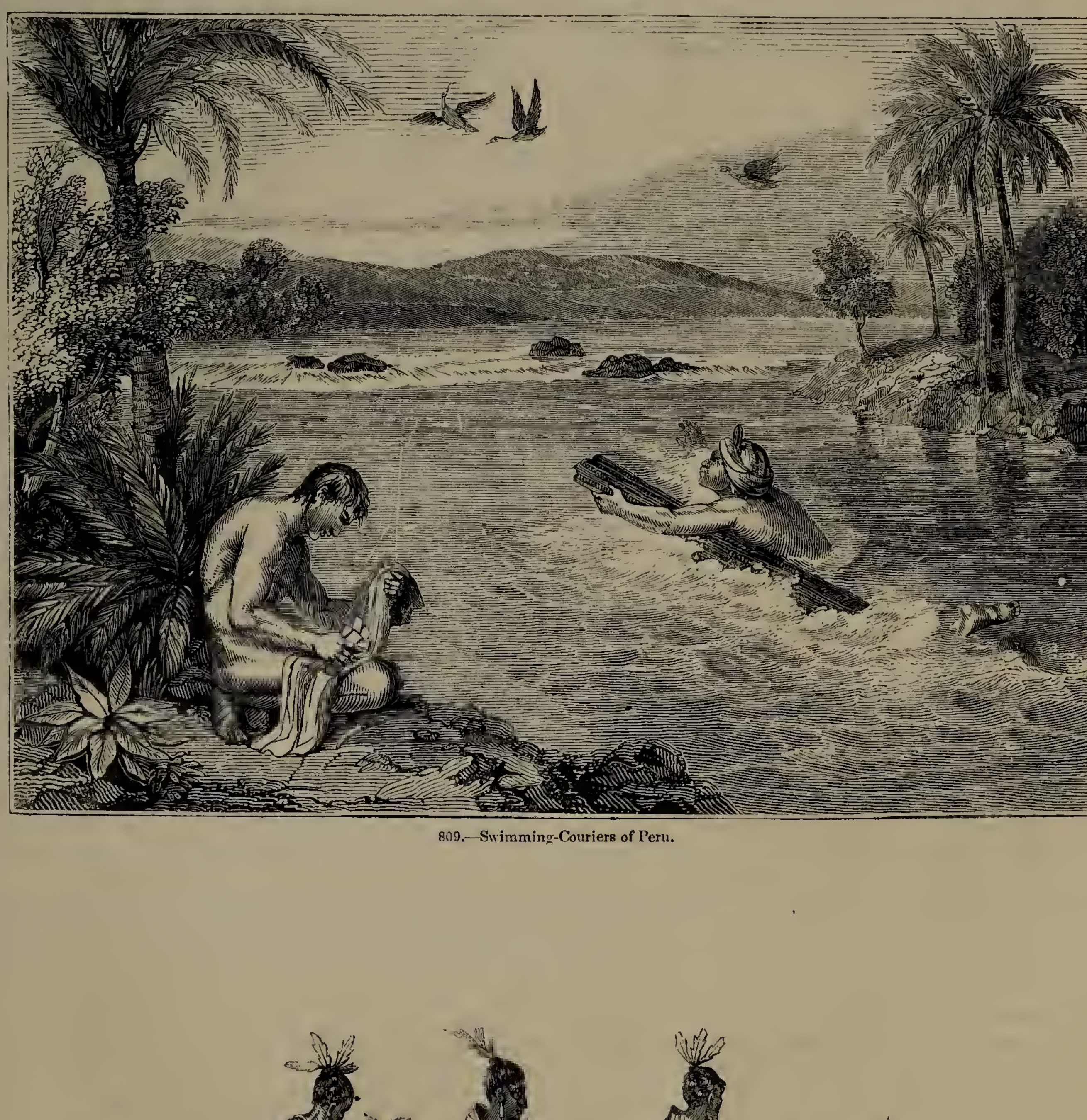
808.—The Jacana, floating on leaves of the Water-lily.

810.—New Zealand Canoe.

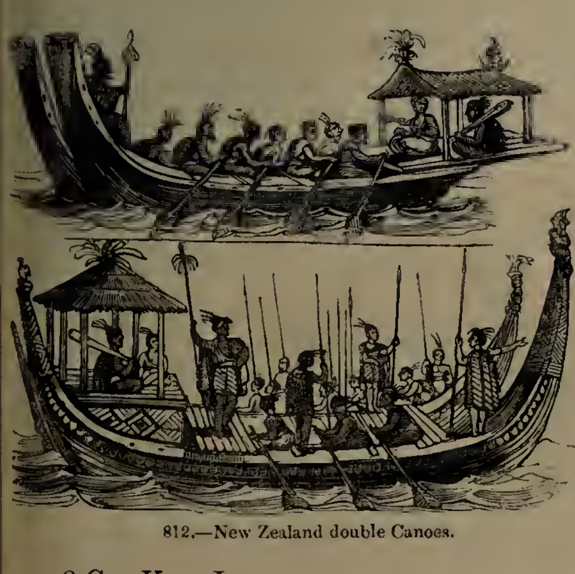


806.—Gnats making boats with their eggs.

807.—Magnified view of Gnat's boat.



809.—Swimming-Couriers of Peru.



812.—New Zealand double Canoes.

811.—New Zealand War-canoe.

with cotton, covered with crimson silk stitched with threads of gold; sheets of white silk, and over all a rich ermine fur. The bedsteads of that day, as to form, are believed to have been similar to the modern children's cribs, being a sort of long box, the side or railing of which was called the "outer bras;" the posts at the corners sometimes rose only a little above this railing, and were ornamented either with panels or by a tester. In the will of Lady Neville, 1385, mention is made of a couvre-lit and a tester of double worsted, and also of a "white couvre-lit and tester powdered with popinjays." Other wills, the production of the same century, make allusion to beds of surpassing richness, such as of black satin, of blue or white silk, of black velvet, of embroidered stuffs; and the widow of Edward the Black Prince, in a will made in 1385, bequeaths to "my dear son the King (Richard II.) my new bed of red velvet, embroidered with ostrich feathers of silver, and heads of leopards of gold, with boughs and leaves issuing out of their mouths." Clocks that chimed the hour formed part of the furniture of a mansion as early as the thirteenth century. Gold and silver were much employed for cups, bowls, basins, ewers, dishes, chargers, salt-cellars, spoons, lavatories, spice-plates, and other articles of table-plate. The screens with feet and stands, and fire-dogs or andirons, were common.

Advancing another century onward, we find that a return was made to the use of embroidered hangings for walls, instead of the paintings which were in fashion in the fourteenth century. The use of tapestry (as noticed in the last chapter) became by degrees more or less prevalent, and transferred to the hands of artizans that which had before been done by the fingers of noble ladies. Curiously carved chairs and stools, tables, buffets, reading-desks, coffers—all belonging to this period, have been engraved from various specimens either still existing or represented in manuscripts. In a will, made by a titled lady in 1434, an enumeration of bed-room furniture runs thus: "A bed of gold swans, with tapettes of green tapestry, with branches and flowers of divers colours; and two pairs of sheets of Raynes (Rennes, in Britanny, where very fine linen for sheets was at that time made), a pair of fustians, six pairs of other sheets, six pairs of blankets, six mattrasses, six pillows, and with cushions and bancours that longen to the bed aforesaid; a bed of cloth of gold with lebardes, with those cushions and tappettes of my best red worsted that belong to the same bed and bancours, and formez that belong to the same bed; also four pairs of sheets, four pairs of blankets, three pillows, and three mattrasses; a bed of velvet, white and black, paled with cushions, tapettes, and formez, that belong to the same bed . . . . My bed of silk, black and red, embroidered with woodbined flowers of silver, and all the casters and apparel that belongeth thereto; twelve pairs of sheets of the best cloth I have, save Reynes, six pairs of blankets, and a pane of minever." This "pane" and the more modern "counterpane" seem to have been two varieties of the same sort of coverlit.

English Furniture from the Sixteenth Century.

During the sixteenth century, from the time of Henry VII. to that of Elizabeth, several changes in domestic furniture were introduced. Round tables with a pillar and claw are represented in paintings of the time, as also are folding-top tables. Fine specimens of richly carved buffets, and others of a plainer character, have likewise been depicted as of that date. At Goodrich Court, Penshurst, and others of the old English mansions, many articles of furniture yet exist to show the fashions in vogue in the sixteenth century; such as a carved table at Leeds Castle; a bedstead at Lovely Hall near Blackburn; a clock at Hampton Court; a curious table-clock of gilt metal at Goodrich Court; a napkin-press, fire-dogs, and a fender at the same place; chairs and couches in many such mansions. Straight high-backed arm-chairs, with the centre and bottom stuffed and covered with velvet, are of this century. Looking-glasses became an article of domestic furniture at this period. Meyrick says, "Mirrors of polished steel had been known to the ancients, and were still used, set in silver or ivory, until the commencement of the fifteenth century; but these were very small, and merely to hold in the hand; . . . but suspended looking-glasses were afterwards imported from France. Thus, in the privy-purse expenses of Henry VIII. in 1532, we meet with 'payment to a Frenchman for certayne looking-glasses;' and at Goodrich Court is a fine specimen of one of the time of Queen Elizabeth." Belonging to the same century are many allusions to carpets, such as "carpets of English work, with arms in the centre;" "a square bound carpet-cloth for the table, with arms in the midst of it;" "one large carpet for a coop-bord;" "carpets fringed with crewell," &c. Turkey carpets are mentioned as early as the reign of Edward VI., and are frequently alluded to in that of Elizabeth; but they were used more for covering tables than floors. The floors of moderate or humble apartments were generally strewed with rushes, and those of state-rooms with matting, a rich carpet or cloth being spread before the throne.

By the seventeenth century the mansions of the nobility and gentry acquired a splendour of fitting and furnishing which they had not before displayed, and of which abundant evidence is even yet to be seen in some of the well-preserved old manor-houses. The materials and nature of the articles of furniture then belonging to the great are to a considerable extent illustrated by a sort of inventory drawn up on the occasion of the marriage of the Princess Elizabeth, daughter of James I., to the Elector Palatine. Among the items are—"To William Brothericke, our embroiderer, for embroidering one whole suit of hangings upon crimson velvet, richly garnished and broidered all over with cloth of gold and cloth of silver, laces of gold, partly with plates, and chain-lace of gold without plates, Venice twists, and gold and silver and coloured Naples silk; for embroidering the several parts of a sparver bed of crimson velvet as the head part, ceeler, double valance, and curtains of velvet and satin; a very large cupboard-cloth of crimson velvet, carpet and screen cloth, chair, stools and cushions, all very richly garnished all over with cloth of gold, cloth of silver, and coloured satin . . . . Item, to John Baker, our uppolsterer, for making a suit of hangings of crimson velvet, containing five pieces and two window-pieces embroidered, lined with dyed canvas; . . . . for making one cupboard cloth, one carpet, and one screen-cloth of like crimson velvet, embroidered, all lined with taffeta, and garnished with fringes of gold and silk; for making two large window curtains of crimson damask, lined with fustian, copper rings, lyer of thread, and other necessaries to them; . . . . . for one bed, one bolster, and two pillows of Milan fustian filled with down, sewed with silk; three quilts of fustian cased with taffeta, filled with wool and sewed with black silk; two pairs of blankets of Milan fustian of five breadths, and five yards long the piece, sewed with silk; two pairs of fine Spanish blankets; . . . . . two counterpoints of plush, both sides alike sewn with silk . . . . . Item, to Henry Waller, for one frame for a canopy for a cushion cloth, with iron-work to it, for the timber-work of one chair, two low stools, and two little tables; . . . . . for one folding-table of walnut-tree," &c.

Hangings of paper and of leather for rooms came into fashion early in the seventeenth century, and, in addition to this, the walls of the best rooms in large mansions came to be enriched with paintings by the great Flemish masters, and by many of the Italian. Ornaments of chinaware also became favourite appendages to the furniture of rooms. Even up to this time, however, the general covering for floors was a strewed layer of rushes or a piece of matting, the use of Turkey and Persian carpets being limited to tables, and to a few special instances on floors. It was about this time too that the custom became established of painting the ceilings of rooms with historical or allegorical subjects. The visitors to the British Museum have still an opportunity (though that opportunity will probably now be of very short duration) of seeing a specimen of such an art in the painted ceiling of the principal staircase in the old part of the building.

During the latter part of the same century the establishment of the tapestry manufacture at the Gobelins gave a new feature to the interior fittings of English mansions; for the walls of rooms, among the wealthy classes, became by degrees decorated with specimens of this art. As to floors, the general prevalence of rushes and matting in lieu of carpets was still observable, a carpet being regarded much more as a covering for a table than for a floor. The figured and painted oil-cloth or floor-cloth, described in an earlier page, was in all probability a later invention; but there was a material known as "oil-cloth" so early as the year 1660. In the 'Mercurius Politicus,' a newspaper published at that time, the number for February 2, 1660, has the following advertisement:—"Upon Ludgate Hill, at the Sun and Rainbow, dwelleth one Richard Bailey, who maketh *oil-cloth* the German way; and is also very skilful in the art of oiling of linen cloth, taffeta, woollen, &c., so as to make it impenetrable that no wet or weather can enter." It is much more probable that this material was used for such purposes as the "oil-skin," "oiled-silk," and "oiled-leather" of modern times, than that it constituted floor-cloth.

The early half of the last century exhibited in its highest perfection that rich and picturesque style of household furniture which has been since known as the "Louis Quatorze" style, and which has been revived to so large an extent within the last few years. The furniture was, as a general rule, made in a very superior manner, in respect both to elegance of form and durability of material. A considerable change arose out of the introduction of mahogany as a wood for furniture. A block of this wood having come into the possession of Dr. Gibbons, a physician of London, he caused it to be worked up into a cabinet, and the beautiful appearance of the wood when polished attracted so much admiration that mahogany became by degrees substituted for the ebony and walnut-tree, which had before been so largely employed for such a purpose. It also became employed for the embellishment of churches and other public edifices, of which many instances are still to be seen in the richly carved mahogany pulpits, galleries, balusters, columns, doors, &c. of large buildings. The love of porcelain ornaments became at that time almost a passion, for the walls of rooms were frequently decked with small brackets, following the course of the panels, on each of which was placed a cup, a saucer, a jar, or some other kind of china ornament. The comedies of Queen Anne's reign contain numerous allusions to ladies of quality purchasing chinaware cups, jars, monsters, and mandarins. Candlesticks, inkstands, hand-bells, and a number of other useful (or useless, as the case might be) articles were also occasionally made of porcelain. Articles of flint-glass were manufactured in our own country, but for looking-glasses we were indebted to Venice until a much later period. The manufacture of carpets at Kidderminster commenced in 1745; and by the end of the reign of George II., the better rooms of most respectable houses were carpeted.

Many of the above details, as to the ornamental character of the furniture prevalent about the sixteenth and seventeenth centuries, are illustrated by Figs. 790 and 791, and by the next two pages of wood-cuts, where chairs, tables, stools, cabinets, bedsteads, chests, and articles of plate and ornament, are represented—all copied from actual specimens existing at the present day, but grouped together in a convenient manner. The groups in Figs. 791, 796, 797, 799, 803, and 804, are formed from various beautiful articles of furniture at Penshurst, Knole, and elsewhere, disposed so as to show their general form and character. Three keys belonging to Dover Castle, shown in Fig. 792, are given as an example of the tendency in past times to give ornamental device to articles which are customarily made plain in our own day. Figs. 793, 794, and 802, may be regarded as articles of plate, remarkable in one way or other for their ornaments. Of the last of these, the "salt-cellar" of Queen Elizabeth, we may remark that about that period the salt-cellar was rather a massive piece of table plate, having a cover nearly as large as itself; it was evidently deemed an important adjunct to the dinner-table, occupying a particular place near the top; and the places of the guests, according to their relative ranks, were determined by being "above the salt" or "below the salt," the former being the most honourable and honoured. Another of the Cuts (Fig. 800) represents the "great bed at Ware," a piece of furniture which has acquired the reputation of being a wonder in its way, and whose large size was made subject of allusion so far back as the period when Shakspere wrote his 'Twelfth Night.' It is a fine specimen of Elizabethan furniture; it is made of oak, is in good preservation, and has some remains of colour in its frieze; the height is nearly eight feet, and the length and breadth nearly eleven. It is said that a hundred guineas were offered for the bed, to its present owner (who keeps it as an exhibition state-bed at the Saracen's Head Inn at Ware), by the late Duke of Norfolk, with a view to its removal to Arundel Castle; but that the offer was refused.

The Colours and Forms of Furniture and Room-decorations.

Much has been written within the last few years respecting the choice of colours and of forms in the chief articles of household furniture. At present, each individual selects for himself according to what may appear to him beautiful or fitting; but no very considerable progress has been hitherto made in laying down rules of taste to be followed generally. Indeed it is a much disputed question whether such rules could be laid down with anything like general sanction. A few paragraphs may here serve to show the views entertained on these points by writers who have paid some attention to them.

Mr. Pugin makes the following comments on certain kinds of paper-hanging patterns:—"I will commence with what are called Gothic pattern papers for hanging walls, where a wretched caricature of a painted building is repeated from the skirting to the cornice, in glorious confusion; door over pinnacle and pinnacle over door. This is a great favourite with hotel and tavern keepers. Again, those papers which are shaded are defective in principle; for as a paper is hung round a room, the ornament must frequently be shadowed on the light side. The variety of these miserable patterns is quite surprising; and as the expense of cutting a block for a bad figure is equal, if not greater than for a good one, there is not the shadow of an excuse for their continual reproduction. A moment's reflection must show the extreme absurdity of repeating a perspective over a large surface with some hundred different parts of light; a panel or wall may be enriched or decorated at pleasure, but it should always be treated in a consistent manner. Flock papers are admirable substitutes for the ancient hangings, but then they must consist of a pattern without colour, with the forms relieved by the introduction of harmonious colours."

Mr. Loudon, in a work to which we have before had occasion to refer, takes the following view of the rela-

tions which ought to exist between the several parts of a room as to colour:—"Much of the opinion which we form of all objects depends on the effect of the first impressions which we receive from them. Our first ideas of any man or woman, in seeing them at a short distance, are taken from their height and clothing; and our first ideas of a room from its size, and the covering or colour of its floor and walls. Taking the room as a whole, and considering its effect as a picture, the colours of the carpet and of the walls will form the principal masses in the composition, and will necessarily influence every other component part. If the floor and the walls were of the same colour, there would be a deficiency of force and of effect from want of contrast; if they were of different colours, equally attracting to the eye, the effect produced would not be that of a whole; because a whole is the result of the co-operation of different subordinate parts with one principal part. The harmony of the colouring of a room, therefore, can only be produced by the same kind of knowledge which guides an artist in painting a picture. The principles of the art of painting supply the principles for the art of distributing colours in furnishing; but as this art cannot all at once be communicated to the reader, all that we shall attempt at present is to supply him with a few hints, drawn from the usual practice of upholsterers. These are, that neither the colours of the carpet should be so brilliant as to destroy the effect of those of the paper, nor the contrary; and that the curtains should always be of a colour suitable to both. It is not necessary that they should be of the same colour, but that they should be of colours that harmonize, or, in other words, look well together. A very brilliant colour, such as crimson, in the carpet, may have a drab or other subdued colour in the curtains and paper; but then there should be some of the brilliant colour introduced in both, as bordering or ornaments. Thus a room with a bright blue or crimson carpet may have white or yellow or drab curtains and paper; but then a crimson bordering or ornaments should be introduced in them, to harmonize the effect. It would not do, in the case of a blue carpet, to have green curtains or paper, or with the crimson to have scarlet, because these colours do not accord. A green carpet may have black, red, or white curtains, with green borders and ornaments. A yellow carpet may have black curtains, and a dark grey paper with yellow borders and ornaments. Whatsoever will apply to a self-coloured carpet, curtains, or paper, will apply equally well in all cases where those colours predominate. It should never be forgotten that the whole effect of an elegantly furnished room may be destroyed by the selection of a carpet which, though handsome in itself, does not harmonize with the other furniture."

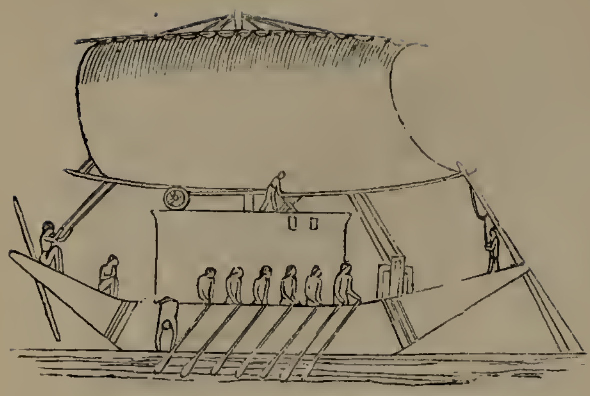
Mr. Pugin, in treating of the relations which interior fittings bear or ought to bear to each other, and to the general purpose of the whole, visits with some severity the usual mode of hanging window-curtains. He says that whatever elegance may be shown in such articles of room furniture, their use should be first considered. This use is, to exclude cold and wind from windows and other openings, and yet to admit of the curtain to be closed or drawn aside at pleasure; and hence there is a rod, on which the curtain may be drawn aside by means of a ring, and a short valance to hang down over the openings above this rod. "Now the materials of these curtains," says Mr. Pugin, "may be rich or plain; they may be heavily or lightly fringed; they may be embroidered with heraldic charges or not, according to the locality where they are to be hung; but their real use must be strictly maintained. Hence all the modern plans of suspending enormous folds of stuff over poles, as if for the purpose of sale or of being dried, is quite contrary to the use and intention of curtains, and abominable in taste; and the only object that these endless festoons and bunchy tassels can answer is, to swell the bills and profits of the upholsterers, who are the inventors of these extravagant and ugly draperies, which are not only useless in protecting the chamber from cold, but are the depositories of thick layers of dust, and in London not unfrequently become the strongholds of vermin. It is not less ridiculous to see canopies of tomb and altar screens set up over windows, instead of the appropriate valance or baldaguin of the olden time. It is proper in this place to explain the origin and proper application of fringes, which is but little understood. Fringe was originally nothing more than the ragged edge of the stuff tied into bunches to prevent it unravelling further. This suggested the idea of manufacturing fringe as an ornamental edging, but good taste requires that it should be designed and applied correctly. In the first place, fringe should never consist of heavy parts, but simply of threads tied into ornamental patterns; secondly, a deep fringe should not be suspended to a narrow valance; thirdly, no valance should be formed entirely of fringe, as fringe can only be supplied as an ornamental edging to some kind of stuff; fourthly, fringe should not be sewed upon stuff, but always on the edges. It is allowable at the very top, as it may be supposed to be the upper edge turned over."

Mr. D. R. Hay, of Edinburgh, in his 'Treatise on Harmonious Colouring,' dwells on the importance of so selecting colours in a room as to form a consistent and harmonious whole. He also insists on the point, that the colouring of rooms should be an echo to their uses: the colour of a library ought to be comparatively severe; that of a dining-room, grave; and that of a drawing-room, gay; while light colours are most suitable for bed-rooms. He also adds, "Apartments lighted from the south and west, particularly in a summer residence, should be of a cool tone; but the apartments of a town-house ought all to approach towards a warm tone, as also should be such apartments as are lighted from the north and east of a country residence. When the tone of an apartment is, therefore, fixed by the choice of the furniture, it is the business of the house-painter to introduce such tints for the ceilings, wall, &c. as will unite the whole in perfect harmony; and this, it may be observed, is a difficult task. The colours of the furniture may be arranged by a general knowledge of the laws of harmony, but the painter's part can only be done by the closest attention to all the minutiæ of the art."

The late Sir John Robison, of Edinburgh, sent to Mr. Loudon, for insertion in the 'Encyclopædia of Villa Architecture,' a description of a drawing-room which he had caused to be decorated, with especial reference to what was deemed by the artists the proper harmony of colouring in the principal parts. There were only three decided colours throughout, viz. white, crimson, and green. The ceiling, cornices, woodwork, and canopies of the window-hangings were white, enriched with gilding; the hangings, the ground of the walls, and that of the carpet, crimson, while the pattern on the carpet was a sort of tracery of creeping plants in shades of green. The chimney-piece was of white marble, reaching nearly to the ceiling, with a panel, equal in width to the opening of the chimney, filled with a mirror or looking-glass. The walls of the room were painted in imitation of Morocco leather, enriched with roses in gilding, shaded by hand, and the whole varnished with copal. The woodwork was dead white, bordered with gilt mouldings. The window-curtains were of a very simple form, being merely large curtains without draperies or fringes, and they hung in vertical lines so as to catch no dust. They ran on gilt wooden poles, and inside the cornice was a common French curtain-rod, on which ran a very fine but plain muslin sun-curtain, edged with crimson cherry fringe. The cords for drawing the curtains, instead of being concealed, are made very conspicuous, and contribute much to the general effect: they are about the thickness of half an inch, of plaited worsted cord, with handsome termination. In speaking of the general colours adopted throughout, Sir J. Robison observes: "The whole of the crimson is, as near as practicable with the different materials, of the same hue, the lake for the walls having been first procured, and the silk and worsted dyed to match it. From this circumstance, and from its being contrasted by the green, and relieved by the white and gold, it has no more of a predominant hue in the arrangement than is perfectly agreeable, while it gives great distinctness in the pictures, and a general air of warmth and comfort, without appearing glaring or gaudy. In the design and construction of everything in the room, the aim has been to avoid harbourage for dust.

In tracing the principles on which the early English builders are supposed to have acted in the construction of churches and edifices, Mr. Pugin states that they adapted their designs to the kind of materials employed, and made no attempt to hide any of the latter. With us, hinges, locks, bolts, and nails are, as far as possible, hidden from view, as if unsightly; whereas in the "pointed" style (whether of architecture or of room-decoration) they were rendered conspicuous features in the general design. The hinges covered the whole face of the doors with varied and flowing scroll-work; a lock was made the object of much curious decoration; and the key was often cast or carved with emblems appropriate to the purposes of the lock belonging to it. Mr. Pugin adduces as an argument in favour of carving instead of metal-castings wherever both may be used, that "all castings must be deficient of that play of light and shade consequent on bold relief and deep sinkings, so essential to produce a good effect. Cast-iron is likewise a source of continual repetition, subversive of the variety and imagination exhibited in pointed design: a mould for casting is an expensive thing; once got, it must be worked out. Hence we see the same window in greenhouse, gate-house, church, and room; the same strawberry leaf, sometimes perpendicular, sometimes horizontal, sometimes suspended, sometimes on end; although, by the principles of pure design, these various positions require to be differently treated." Whether or not, according to any particular theory of the principles of art, the employment of castings leads to the heterogeneous mixture of things that ought to be kept separate, we must not forget that the power of rapid and cheap production, possessed by and inherent in the system of casting—whether ornamental impressions from a mould, or printed impressions from a stereotype plate—has been, and is, one of the most powerful of all means for diffusing among the many that which had before been attainable only by the few.

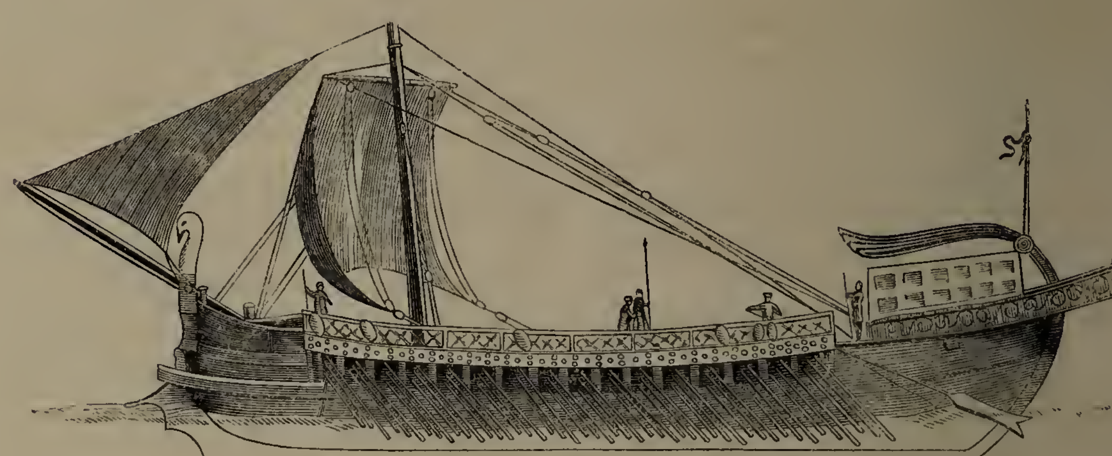
In bringing this Chapter to a conclusion, we may remark that it has not been so much the object to trace step by step all the mechanical processes connected with the building, decorating, and furnishing of a house, as to take a broader view of the general relations which the various groups of processes bear one to another, and to the higher or decorative branches of art. In this, as in most other subjects, there is abundant scope for uniting mechanical art with elegant or fine art; and the Government School of Design, both at its central and at its branch establishments, is aiding in the (now general) attempt to make the connexion yet more intimate, so as to elevate productive industry to a point far above a standard of mere and bare utility.



813.—Ancient Ship. (From an Egyptian Painting.)

816.—" Flying Proas " of the Ladrone Islands

814.—Ancient Ship. (From a bas-relief at Pompeii.)



815.—Ancient Ship. (From a Painting at Pompeii.)

818.—Chinese Cargo-boat.

817.—Double Canoes of Tahiti or Otaheite

819.—Ferry-boat on the Nile

826.—Chinese Chop-boat.

821.—Chinese Flower-boat.

825.—Chinese Trading-junk.

822.—Chinese Sanpan.

820.—Canoe off Cape Wangari, New Zealand

823.—Chinese Pleasure-barge.

824.—Chinese Trading-junk.

CHAPTER V.

THE ARTS RELATING TO SHIPS AND SEA-TRAVELLING.

When an attempt is made to analyse the industrial arts, to separate and classify the various applications of ingenuity to useful purposes, it cannot fail to be remarked that the *maintenance of intercourse* between places locally separated occupies a very notable share of capital, skill, invention, and commercial enterprise. That system which, at the present time, seems to absorb more attention than almost any other in commercial matters—viz. the railway system—is nothing more in principle than the transit regulations of every country, whether the canoe-paddling of a South Sea Islander or the fourpenny trips of a Thames steamer, whether the mule-sedan of the Pyrenees or the "cab" of the London streets. The mighty works which the genius of a Stephenson or a Brunel has added to the mechanical wonders of the age, in respect to railway engineering; the system which Brindley and his patron Bridgewater founded in respect to canal navigation; the roads and bridges which Telford and Rennie constructed in so many parts of the country; the marvels of steam-navigation, which have enabled a ship to travel from America to Liverpool in ten days—all are but extensions (when their object is duly considered) of the same principle that leads to the building of canoes, boats, barges, and ships; the construction of docks, harbours, quays, breakwaters, and lighthouses; the making of sails, ropes, anchors, and nautical instruments; the building of coaches, omnibuses, carts, and waggons; and the establishment of the stage-system, the mail-system, the posting-system, the carrier-system, the post-office system, and the telegraph-system—with its last and grandest improvement, the electrical agency. While the other industrial arts enable men to produce commodities of value out of the crude productions of the earth, these afford the means of general diffusion, and enable every country and every town to share more or less fully the advantages of every other: there is a perpetual contest between man on the one hand, and time and distance on the other; and we have no reason to be ashamed of the result of the contest.

In the present Chapter many of the arts bearing upon sea-travelling will occupy our attention; in the next, those which relate more particularly to land-travelling will come under review; while other matters more or less connected with the subject will find a place in a subsequent Chapter.

It may, perhaps, be convenient to group the contents of this Chapter as follows:—Ships and Boats of Foreign Countries—Progress of English Ships and Ship-building—Construction of Vessels and their Appendages—Canal and Steam Transit; each of which will afford materials for much instructive detail.

SHIPS AND BOATS OF FOREIGN COUNTRIES.

There is perhaps not a nation on the face of the earth ignorant of the mode of making a vessel capable of floating on the surface of the water; if we except some few tribes in the interior of a country. Nor can we tell with any degree of clearness which among the nations of early times had not such knowledge. Charnock observes that—"It would be a fruitless attempt to investigate, not merely the first inventor of marine architecture, but even the country or quarter of the world from whence the science derived its birth or origin. The remote distance of time, aided by the hyperbolical fictions of poets and historians, renders the attempt absurd, and indeed ridiculous, because the result of the inquiry cannot produce any decisive determination. It may be conjectured that the inquisitive, active spirit of enterprise, constitutionally as it were implanted in our nature, displayed itself at one and the same time in a variety of quarters and districts; for the primitive ideas of men dispersed over the face of the globe, unconnected with each other, and totally ignorant even of each other's existence, appear in such perfect unison as to invention, that they extremely well warrant this supposition."

Primitive Examples of Floating.

Every one who watches the habits of the lower animals has opportunities of observing many examples of buoyant movement on the surface of the water, calculated to give instructive hints. The whole tribe of fishes are enabled to float by the presence of some kind of air-vessel within the body; the entire bulk being heavier or lighter than an equal bulk of water according to the less or greater fulness of the air-vessel. This, however, is a natural conformation, owing nothing to the skill of the animal.

There is a curious instance furnished by the gnat, of the construction of a little boat by means of its eggs. Mr. Rennie ('Insect Transformations') says that the problem which the insect has to solve is to construct a boat-shaped raft of eggs, which, though heavy enough to sink when dropped in the water singly, shall be able to float when laid side by side; and he states that the best time to witness the operation is before five or six o'clock in the morning, and the best place is any pond or piece of stagnant water where gnats frequent. The work proceeds as follows:—The eggs are nearly of the pyramidal form of a pocket gunpowder-flask, rather pointed at the upper and broad at the under end, with a projection like the mouth of a bottle. The first operation of the mother-gnat is to fix herself by the fore legs to the side of a bucket, or upon a floating leaf, with her body level with and resting upon the surface of the water, excepting the last ring of the tail, which is a little raised; she then crosses her two hind legs in the form of an X, the inner opening of which is intended to form the scaffolding of her structure. She accordingly brings the inner angle of her crossed legs close to the raised part of her body and places in it an egg, covered, as is usual among insects, with a glutinous fluid. On each side of this egg she places another, all which adhere firmly together by means of their glue, and form a triangular figure, which forms ultimately the stern or hinder end of the raft. She proceeds in the same manner to add egg after egg in a vertical (not a horizontal) position, carefully regulating the shape of her crossed legs; and as her raft increases in magnitude, she pushes the whole gradually to a greater distance; and when she has about half finished, she uncrosses her legs and places them parallel, the angle being no longer necessary for shaping the boat. Each raft consists of from two hundred and fifty to three hundred and fifty eggs, which, when all laid, float on the water secure from sinking, and are finally abandoned by the mother.

Here, then, is an example of the tact which instinct gives to these little animals in the construction of a framework which shall float on the surface of water for a limited period. The object in view is to make the eggs aid each other in keeping afloat, and not as a means of transport. The eggs are hatched in a few days, the grubs issuing from the lower ends; but the boat, now composed of the empty shells, continues to float till it is destroyed by the weather. Mr. Kirby describes this little egg-boat as resembling a Thames wherry, being sharp and high at the two ends, convex below, and concave above, and always floating on its keel. "The most violent agitation of the water," this naturalist observes, "cannot sink it; and what is more extraordinary, and a property still a desideratum in our life-boats, though hollow, it never becomes filled with water, even though exposed. To put this to the test, I placed half a dozen of these boats upon the surface of a tumbler half full of water; I then poured upon them a stream of that element from the mouth of a quart bottle held a foot above them. Yet after this treatment, which was so rough as actually to project one out of the glass, I found them floating as before upon their bottoms, and not a drop of water within their cavity." Mr. Rennie says, too,—"We have repeatedly pushed them to the bottom of a glass of water, but they always came up immediately to the surface apparently unwetted." In Fig. 806 are represented three of these nests; *a* being the commencement of an egg-boat; *b*, a boat about two-thirds completed; and *c*, a perfect boat resting on the surface of the water. Fig. 807 gives a magnified view of one of the boats.

Other kinds of insects, as also birds, frequently avail themselves of means for travelling on the surface of the water. Fig. 808 represents a bird walking on the broad leaves of the water-lily on the surface of the water. Mr. Rennie states that many insects are provided with the means of walking on the water itself; the whirling-beetle, for instance, urges himself along the water by a peculiar and rapid moving of his feet upon the surface. "We have been amused," he says, "with a dark greenish grey spider, which, when we approach near its haunts on the banks of a stream, does not take shelter in the grass, nor in the holes of the bank, as most of its kindred would do, but trips away over the water, where it appears to know instinctively that we cannot so easily pursue it. . . . . Some of these water-insects have such slender feet, that we can only explain their not sinking in the water on the same principle as that of a small needle floating when very dry and laid exactly level; others again have their feet fringed with fine hairs, which buoy them up." The same writer also states that the Rev. Robert Shepherd has often noticed in the fen ditches of Suffolk a very large spider which actually forms a raft for the purpose of obtaining its prey with more facility. Keeping its station upon a ball of weeds about three inches in diameter, probably held together by slight gossamer filaments, it is wafted along the surface of the water upon this floating island, which it quits the moment it sees a drowning insect. The booty thus seized it devours at leisure upon its raft, under which it retires when alarmed by any danger.

There are some occasions where swimming takes precedence of boat-building among rude nations. Thus Humboldt describes a system which we may perhaps regard as the most primitive form of "post-office," and which is at the same time the simplest of all species of navigation. In order to maintain a communication between the shores of the South Pacific and the province of Jaën de Bracamoros, Indians are employed, who during two days descend the river Guancabamba, or Chamayá, and afterwards the Amazon river as far as Tomependa. The courier, before he commits himself to the water, wraps the few letters with which he is charged monthly sometimes in a handkerchief, and at other times in a species of drawers called guayuco, and this he disposes in the form of a turban round his head. In this turban he also places the large knife or cutlass with which he is always provided, less as a means of defence than to assist him in clearing the underwood while making his way through the forests. The Guancabamba is not navigable, on account of a great number of falls and rapids; these the Indian passes by land, taking again to the water as soon as all danger from them is over. To assist him in swimming, he provides himself with a log of very light wood (Fig. 809), generally the trunk of the bombax. These men, who are known in the country as "swimming-couriers" (el correo que nada), have no occasion to encumber themselves with provisions, their wants being abundantly supplied by the hospitable inhabitants of the cottages which they pass on the banks of the rivers.

The art of swimming is much practised by the natives of many of the Pacific and Atlantic islands. Captain Cook described an extraordinary amusement of this nature pursued by the natives of one of the Sandwich Islands. For a distance of a hundred and fifty yards from the shore of one of the bays there is a surge of exceeding violence; and whenever, either from stormy weather or from any extraordinary swell at sea, the impetuosity of the surf is at its highest, the natives choose this time for their rather venturesome sport. Twenty or thirty of them, taking each a narrow board rounded at the ends, set out together from the shore. They plunge under the first wave they encounter, and, suffering it to roll over them, rise again beyond it, and make the best of their way by swimming out into the sea. The second wave is encountered in the same way with the first; the great difficulty consisting in seizing the proper moment of

diving under it, which if missed, the person is caught by the surf and driven back again with great violence, and all his dexterity is then required to prevent himself from being dashed against the rocks. As soon as they have gained, by these repeated efforts, the smooth water beyond the surf, they lay themselves at length on their board and prepare for their return. As the surf consists of a number of waves, of which every third one is remarked to be always much larger than the others, and to flow higher on the shore, the rest breaking in the intermediate space, their first object is to place themselves on the summit of the largest surge, by which they are driven along with amazing rapidity towards the shore. If by mistake they should place themselves on one of the smaller waves, which breaks before they reach the land, or should not be able to keep their plank in a proper direction to the top of the swell, they are left exposed to the fury of the next, and to avoid it are obliged again to dive and regain the place from which they set out. Those who succeed in their object of reaching the shore have still great danger to encounter; the coast being guarded with a chain of rocks, with here and there a small opening between them, they are obliged to steer their board through one of these, or, in case of failure, to quit it before they reach the rocks, and, plunging under the wave, make the best of their way back again.

Adanson, in his 'Voyage to Senegal,' relates a similar anecdote as to the swimming powers of the negroes in those parts:—"The negroes are all excellent swimmers; and nothing can be a stronger proof of this than the intrepidity with which they expose themselves on the bar. I was on the sea-shore, busied in observing the height of the equinoctial tides, when a French vessel arrived opposite to the fort of Senegal. The ship's boat advanced towards the bar, and there waited till somebody from shore came to see what despatches it brought. The negro, who was used to this business, jumped into the water to fetch the letters, though there was a greater swell than usual, because the tides rose to a higher pitch. To behold the violent agitation of the sea, the billows rising above ten feet, and then falling like so many sheets of water with prodigious noise and weight, one would never imagine that he could possibly surmount them: yet he passed them all, riding upon the backs of some, and plunging under others, where he seemed to be buried, till at length he happily got on shore with the despatches committed to his care."

The most extraordinary swimmer, perhaps, of whom any record has been kept, was a Sicilian named Nicolo Pesce, of whom an account has been given by Kircher. He often swam over from Sicily to Calabria, which is a tempestuous and dangerous passage, carrying letters from the king; he also frequently swam among the gulfs of the Lipari Islands. Kircher's account is, however, almost too marvellous to follow; for he says that Pesce was known frequently to spend five days in the water; that he supported himself by eating the raw fish which he caught while swimming about; and that "in aid of these powers of enduring the deep, nature seemed to have assisted him in a very extraordinary manner; for the spaces between his fingers and toes were webbed as in a goose; and his chest became so very capacious, that he could take in at one inspiration as much breath as would serve him a whole day!" We may safely give Nicolo the credit of having been a good swimmer, without being compelled to believe all these wonders.

Ships and Galleys in Ancient Times.

The precise determination of the form and management of ancient vessels, in the countries bordering on the Mediterranean, has never yet been clearly effected, owing mainly to the exaggerated statements from which alone inference is to be drawn. Allusions are contained in Plutarch to "biremes," "triremes," "quadriremes," and "quinqueremes," implying, respectively, two, three, four, or five rows or tiers of oars; and galleys are said to have been made with fifty such tiers. In what sense these expressions are to be received has sadly puzzled commentators; and very marvellous descriptions have hence been given to the effect that the ancient galleys were sometimes made so lofty as to have fifty decks, or at least sets of benches, one above another for the rowers. Mr. Holwell suggests that a more plausible solution may be found by supposing that the tiers of oars were arranged obliquely up the sides of the vessel, as many oars in each tier as would admit of the highest being rowed with facility; in such case each additional tier would only require additional length in the vessel.

Charnock ('History of Marine Architecture'), comparing the details given by various early writers, says that the vessels used on the Nile by the ancient Egyptians appear to have been formed of small planks cut out of the Acantha, or Egyptian thorn. These were not cut into lengths like planks, but into pieces nearly square, measuring about three feet each way; they were lapped over each other like tiles, and fastened together by a number of wooden pins. This mode of construction was found sufficiently strong for the purposes to which it was applied, without the assistance of any internal frame of timber. The hull of the vessel being thus formed, a sufficient number of seats or benches for the accommodation of the rowers were added; and when the joints or seams were carefully caulked with the papyrus so as completely to exclude the water, the vessel became ready for immediate use.

"These vessels," says Mr. Charnock, "being as well from their construction as their equipment almost incapable of stemming the current of the river (Nile), were generally towed up against it by persons on shore, unless the wind fortunately proved sufficiently strong and favourable for the proposed course, to enable the sail to be used as a substitute. On returning with the current, it was customary for the Egyptians to fasten, with ropes across the prow of the vessel, a hurdle of tamarisk, which being let down into the water, and steadied by ropes or bands made of twisted reeds, caused it to move forward with increased velocity, in consequence of the stream acting with greater force on the surface of the hurdle, which extended beyond the sides, than it would have done on the mere vessel itself without this ingenious aid. In order to observe a due balance between the head and stern, which might otherwise have been affected by the action of the water on the hurdle, and in some degree also by the weight of it, as well as to cause the boat to swim nearly with an even keel, a stone of considerable magnitude, pierced through the middle, was suspended by a rope from the stem, a contrivance which was found to answer the purpose so well, that the unskilled navigators were enabled to pass to and fro without either danger or difficulty."

It is a very probable conjecture that the first form of boat or vessel in most countries was the *raft*: a collection of trees or logs rudely fastened together with ropes, formed most probably from the bark of the very trees which constituted the raft, or from some other coarse material. Experience would soon teach the navigators that they were deficient in the power of directing such a fabric so as to be certain of reaching their place of destination in spite of winds and currents. To remedy this defect a simple addition was contrived, consisting of a few thick planks of wood thrust down into the water to the depth of three or four feet between the logs which formed the raft: these, being raised or lowered according to circumstances, were found to aid him considerably in the management of his vessel. That such was the precursor of the boat or ship is rendered probable by the usages of rude nations in our own day; the less ingenious of whom construct vessels which approach much more nearly to the form of rafts than of boats.

Charnock traces with much minuteness the steps whereby commerce on the one hand, and war on the other, led to improvements in the arts bearing upon ship-building. The Phœnicians, who were among the most enterprising of commercial nations in early times, were also among those who attended most to the improvement of ships; to which, indeed, they owed no small share of their importance. The wars between the Greeks and other nations, separated one from another by the open sea, naturally led to the improvement of vessels in another way, so as to produce the "war-galleys" of classical times, on which so much has been written, and the true character of which is at the present day so little understood. The Greeks had vessels built for a particular kind of merchandise, or for a particular part of the sea, each one having certain peculiarities in respect to its form or size. In the construction of these merchant vessels, the plane, the cypress, the oak, the fir, and the cedar trees were employed.

In building the war-galleys, where stout and strong timber was an essential requisite, a curious idea prevailed as to the proper time for cutting down the oak or fir trees employed. There was a notion that it would be improper to cut down any timber for the purpose of ship-building except on the seventeenth day of the moon; because the moon being then on the wane, the sap or internal moisture, which is the grand cause of early decay, would be sunk or considerably lessened. It was afterwards laid down as a rule, by those who thought they had discovered some connexion between the age of the moon and the state of trees, that the time of cutting might be on any day between the fifteenth and the twenty-third day of the moon's age; but that if these limits were transgressed, the wood so cut down, and afterwards used for ship-building, would decay and become worm-eaten in a very short space of time. Even the direction in which the wind blew was taken into account, and this had its particular rules at different seasons of the year: for example, in the beginning of autumn, it was not considered prudent to cut down trees for this purpose unless the wind was westerly, or, in the winter, unless it blew from the north.

The kinds of wood employed in building the war-galleys were chestnut, cypress-wood, pine, elm, oak, and fir. The hull of every ship and galley consisted of a prow or head, a poop or stern, and body or midship frame. In the early form of vessels, intended chiefly for commercial navigation, there was no keel; they were flat-prowed, round, drawing little water, and of very great breadth in proportion to their length, so as to be able to contain a larger amount of commodities than would be the case under the adoption of any other form. The floor-timbers were contiguous, and there appears to have been some means known, by steaming or otherwise, of bending timber so as to make it conform to the shape of the vessel. But it became apparent by degrees that it would be more available to build up a ship piece by piece; by having a keel or central spine running from end to end, and making a framework by attaching side-ribs to this keel. The separate timbers of this framework rose at right angles from the keel, and planking was put on outside of them, in layer after layer parallel to the keel: the planks being fastened to the ribs by bolts or pins. There was a deck thrown across the vessel, at a height from the keel greater or less according to the size of the hull; and at different parts of the side, between the deck and the water-level, were holes at which the oars were thrust out for rowing the vessel. The disposition of these oars, and the number of them, are the points to which allusion was lately made as having been warmly discussed among the commentators on early writers.

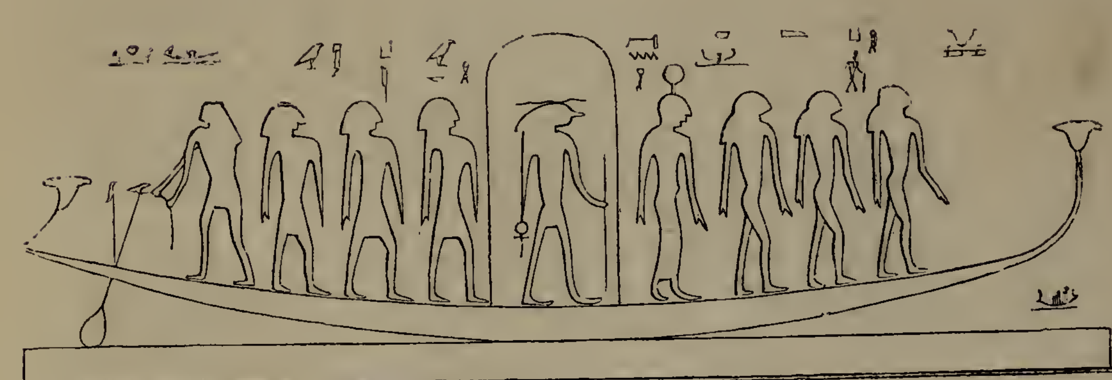
As a means of preventing water from finding entrance between the planking, a stuffing or caulking was rendered necessary. The first application for this purpose among the Greeks is said to have been nothing more than the use of sea-shells, which were reduced to powder, mixed up with water into the state of a paste, and introduced into the chinks; being liable however, to crack, by the yielding of the vessel, this composition fell out by degrees, and soon failed to answer its purpose. The next step was to burn the lime, as a means of making the mortar more adhesive; and afterwards wax and pitch were employed. A far better plan, and one nearly in conformity with modern practice, was found to consist in the use of the coarse outer fibres of the flax-plant, bruised and divided by being beaten with a mallet, and driven in between the planks of the ship. The bottom of the vessel was also, in some cases, coated with a layer of melted wax or pitch. In others, as is stated by Maurice, the ship-builders "were accustomed to use hides, properly prepared and hardened for the purpose, which, being stretched and firmly attached to the bottom, served as a species of sheathing, and, being well payed or covered with a sufficient coat of resin or pitch, proved a very considerable protection to it against those injuries which would have arisen from the salt-water being in constant contact with it."

A curious proof has been brought to light of the existence of the modern practice of "caulking" and "sheathing" ships in early times. Trajan's galley was dug up from the Lake Riccio in Italy, after having lain there thirteen hundred years; and, on being examined, the seams were found to have been caulked with linen, and the whole of the exterior of the vessel to have been carefully coated with Greek pitch, over which was laid an external sheathing of lead, rolled or beaten to a proper degree of thinness, and closely attached to the planking by means of small copper nails.

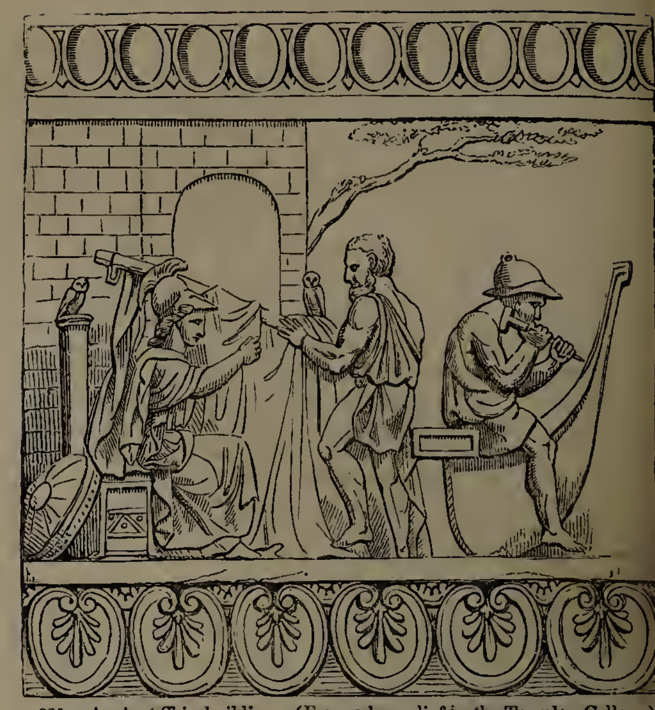
As the commercial vessels of Greece and Rome were chosen rather for capacity and safety than for other qualities, they were formed to pass through the water less rapidly than the war-vessels. Indeed, the war-galleys, using oars only, are said to have surpassed in speed the merchant-galleys even with all their sails employed; and this difference was still more marked when the war-galleys used sails as well as oars. The rostrum, or sharp beak of these galleys, was one of the most formidable weapons of offence in naval warfare; and one of the objects in the mode of navigating, whether by oars or sails, or both, was to impel this beak with immense force against the enemy's galley. By lengthening the beak very considerably the speed of the vessel was increased, and the momentum greater; but the beak itself was, at the same time, weakened by the lengthening, so that the problem to be solved was —how to obtain the greatest speed and impulsive force with the greatest strength of beak. The beak was made of the toughest wood, such as elm, ash, or oak. The mode of attack was either to sheer up suddenly so close alongside the enemy that the stroke of the beak might shatter the oars on the side attacked, and by that means render the vessel in great measure unmanageable; or, by striking the enemy with the greatest possible force near the midship, cause the beak to penetrate the side of the enemy's vessel, or to overset it in case it was fortunate enough to resist the first onset. Sometimes the enemy attempted to steer round the stern, and, by a sudden swift stroke, to demolish or injure the rudder.

The decorations of the stern, or poop, differed very materially from those of the head, and were more magnificent. It was customary, also, to fix at the extremity of it an upright staff or pole, to which were affixed streamers of various colours. It was, moreover, usual among many nations to add some carved ornament, frequently gilt. The sails were often striped with various colours; and, more particularly on board the galley belonging to the commander of the fleet, were entirely purple. Flame-coloured sails were also in use; and so fanciful was the taste in respect to this part of a ship's fittings, that sails were sometimes

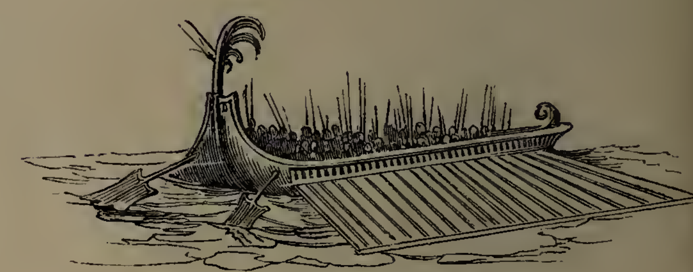
827.—Various Chinese Vessels, at the Port of Shang-hae.



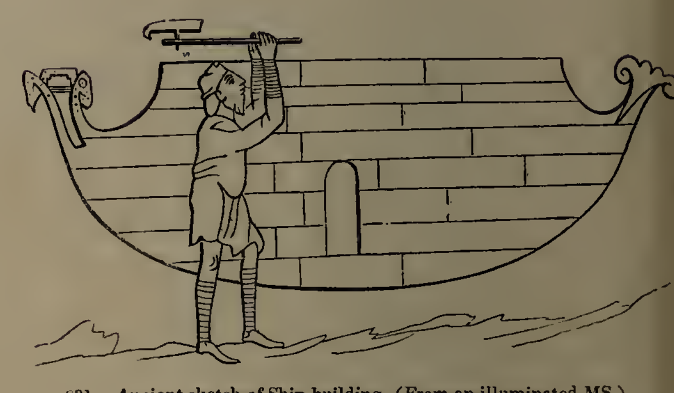
828.—Ancient Vessel. (From an Egyptian Painting.)



829.—Ancient Ship-building. (From a bas-relief in the Townley Gallery.)



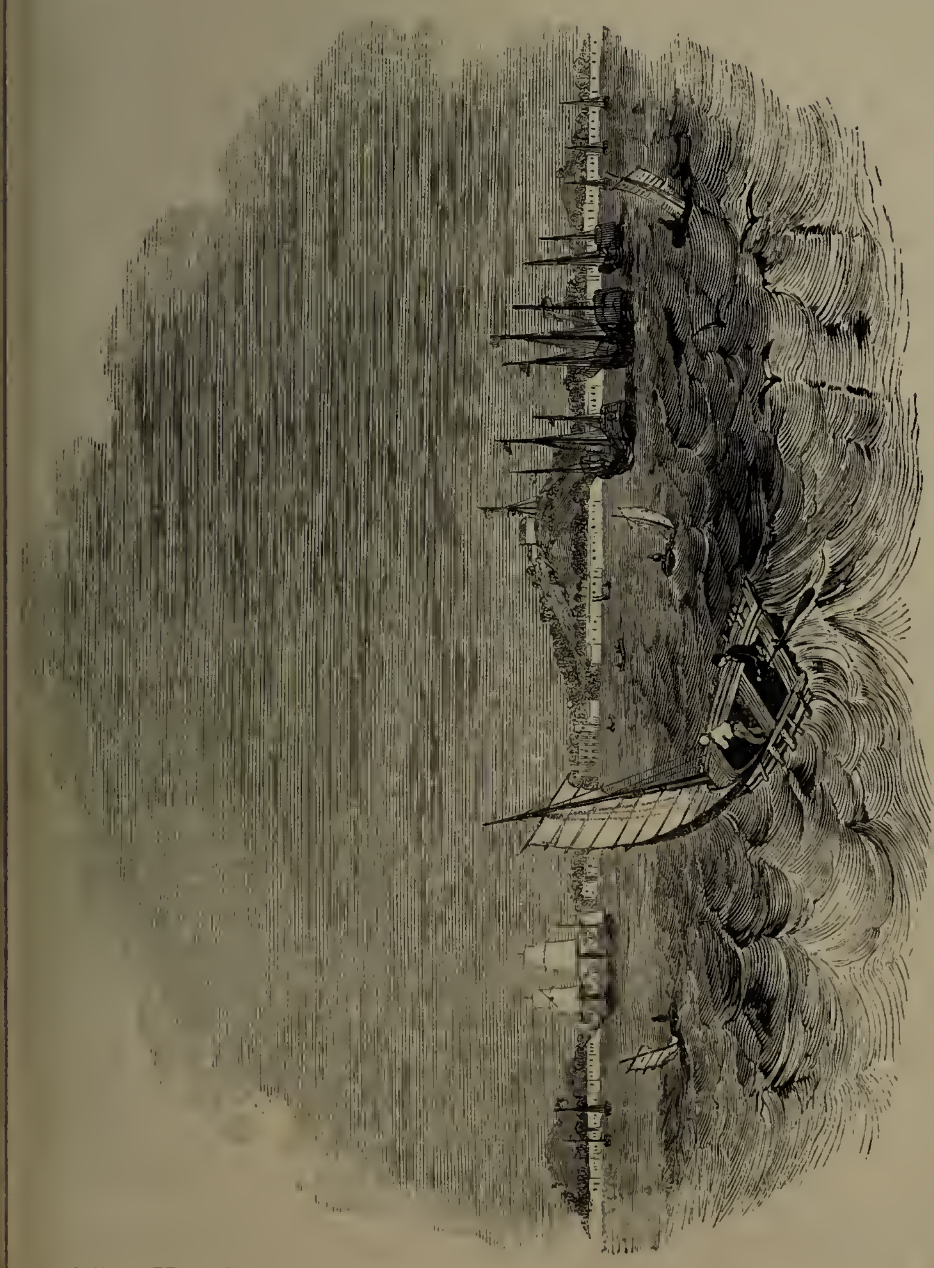
830.—Ancient Galley. (From a Painting at Pompeii.)



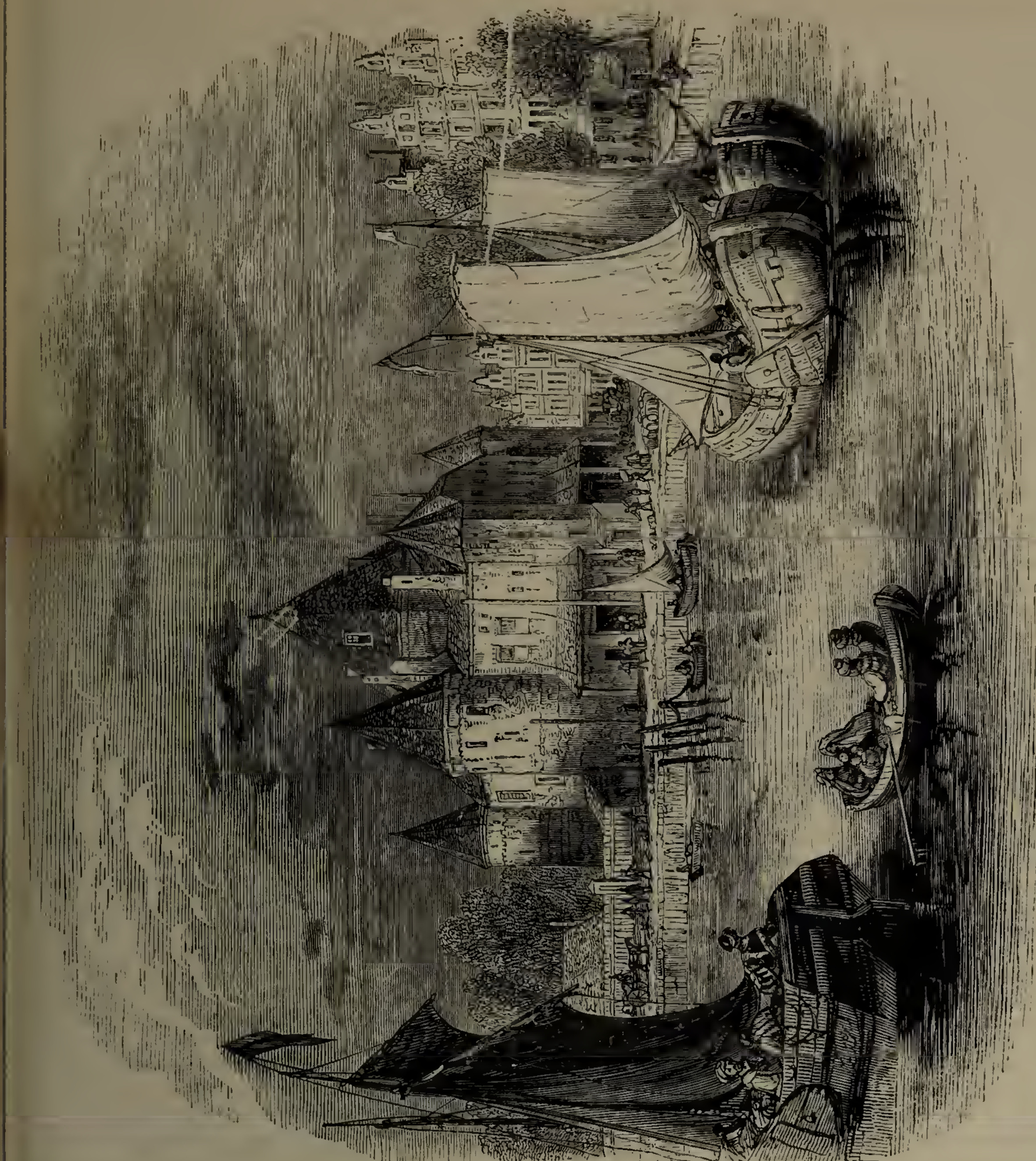
831.—Ancient sketch of Ship-building. (From an illuminated MS.)

832.—Roman Galley. (From a bas-relief.)

833.—Hindoo Boats on the Ganges.

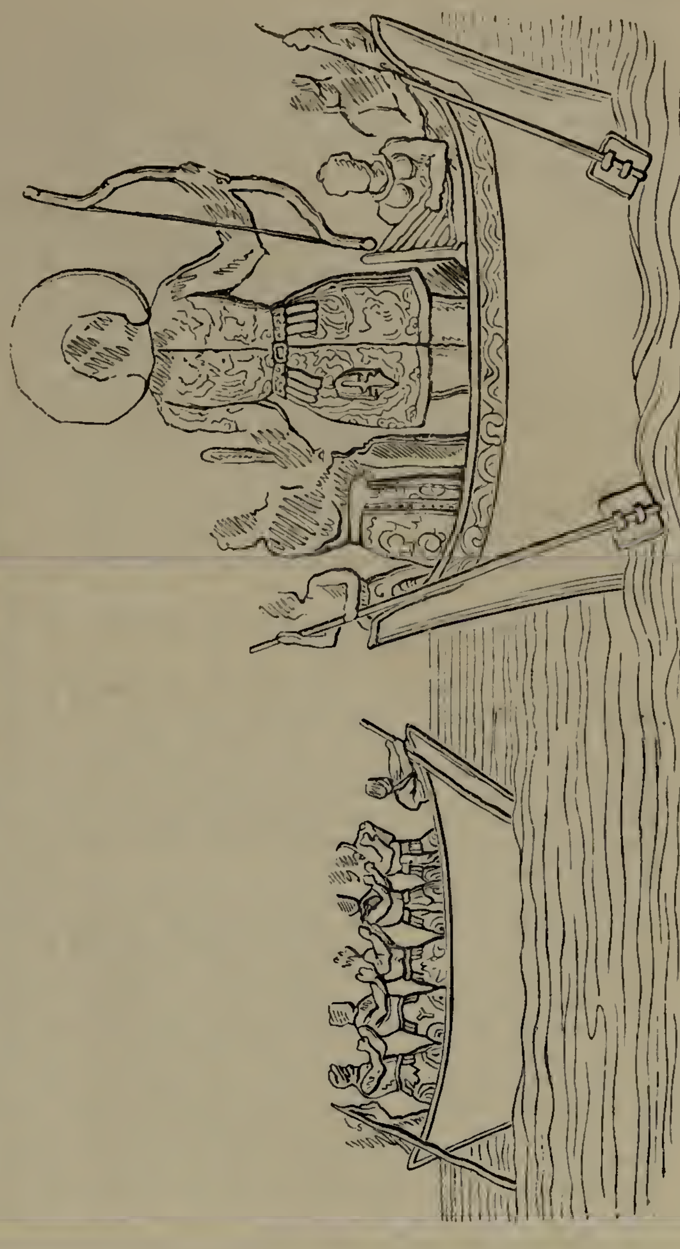


835.—Flat sterned Boats at Singapore.



837.—Dutch Vessels at Amsterdam.

836.—Sailing-boat on the Nile.



834.—Ancien Persian Boats. (From a bas-relief.)

woven of threads previously dyed of different colours, so as to produce that diversity of appearance known as "shot" in reference to silk. In the time of Trajan ideas of luxury were carried so far in respect to these matters, that the name of the emperor was embroidered with gold or silver on the sails of the war-galleys.

The best modes we have of obtaining any notion of the form of ancient vessels is from the paintings and bassi-rilievi at Pompeii, Thebes, and similar places; for however uncouth these representations may appear, they were undoubtedly intended by the artist to convey a correct idea of the vessels. In Figs. 813, 828, we have representations of ships from ancient Egyptian paintings; in Figs. 814, 815, 829, 830, are sketches of Greek and Roman vessels, derived either from Pompeii or from the Townley Gallery at the British Museum; in Fig. 831 we have an odd representation of a shipwright, from an illuminated manuscript; in Fig. 832, a Roman galley, taken from a similar source; and in Fig. 834, a vessel represented on an ancient Persian bas-relief.

Vessels and Boats in the Southern and Eastern Oceans.

The *galleys* of ancient times and the *gondolas* of Venice at the present day form the two ends of a chain which has had numerous intermediate links; for both present certain features in common, bearing some slight resemblance to the "state barges" of our own times. Before speaking of the gondola, however, it may be well to glance at the ruder vessels constructed by more distant nations.

All the navigators who made known to us the existence of groups of islands in the Pacific, the Indian, and other oceans, accompanied their narratives with descriptions of the canoes or other kinds of boats in use among the natives; and means are thus afforded for observing the various ways in which ingenuity is brought to bear on such matters. Whether each nation or tribe made its own discoveries, and applied its own inventive skill, or whether one borrowed ideas from another, and modified them according to circumstances, can now hardly be known; but it is probable that both causes led to the production of the object in view.

Among the Ladrones and others of the Eastern islands a kind of boat is used called a *proa* (Fig. 816). In the account of Anson's voyage this proa is spoken of with marked commendation:—"Whether we consider its aptitude to the particular navigation of these islands, or the uncommon simplicity and ingenuity of its fabric and contrivance, or the extraordinary velocity with which it moves, we shall find it worthy of our admiration, and meriting a place amongst the mechanical productions of the most civilized nation." The proa seems to be constructed on a principle directly the reverse of English vessels; for while we make the head of the vessel different from the stern, and the two sides alike, the proa has the head and stern alike, but the two sides different. There is one side of the vessel which is intended always to be kept to the leeward, and this is flat; whereas the other side is rounded, as in other vessels. To prevent her oversetting, which is likely to happen from her small breadth, and the straightness of her leeward side, there is a frame extending from her to windward, to the end of which is fastened a log, shaped like a small boat, and made hollow; the weight of the frame is intended to balance the proa, and the small boat, by its buoyancy, prevents the oversetting. The body of the proa is made of two pieces joined endwise, and sewed together with bark—there being no iron used about her: it is always about two inches thick at the bottom, and about one at the gunwale. The proa generally carries six or seven men; two of whom are placed in the head and stern, to steer the vessel alternately with a paddle, according to the direction in which it is going; the other men being employed either in baling out the water which she accidentally ships, or in setting and trimming the sail.

The peculiar construction of these vessels arises out of the sort of navigation for which they are intended. The Ladrones are a string of islands lying nearly north and south of each other, and the proas have scarcely to follow any other points of the compass than these two in maintaining intercourse between one island and another. Either end of the vessel may at pleasure be made the head, and thus, by simply shifting the sail, it may go to and fro without ever "putting-about," or turning round. By the flatness of their lee-side, and their small breadth, they are able to lie much "nearer the wind," as sailors say, than other vessels. They have been known to progress, when a brisk trade-wind is with them, at the rate of twenty miles an hour; and this amazing swiftness obtained for them the name of "flying proas."

Captain Cook, while speaking of the canoes of the Friendly Islands, characterized them as being among the neatest he had ever seen at sea. They are built of several pieces, sewed together with much neatness; all the fastenings are on the inside, and pass through kants, or ridges, which are wrought on the edges and ends of the several boards which compose the vessel. At each end is a kind of deck, one-third part of the whole length, and open in the middle; they have all outriggers, similar to that of the proa just alluded to, and are sometimes navigated with sails, but more generally with paddles, the blades of which are short and broad. The "double canoes," however, are the most remarkable. The two vessels which compose the double canoe are each about sixty or seventy feet long, and four or five broad in the middle; and each end terminates nearly in a point; so that the body or hull differs a little in construction from the single canoe, but is put together exactly in the same manner; these having a rising in the middle round the open part, in the form of a long trough, which is made of boards closely fitted together, and well secured to the bottom of the vessel. Two such vessels are fastened together parallel to each other, about six feet asunder, by strong cross-beams, secured by bandages, to support the upper part of the risings above mentioned. Over these beams, and others which are supported by stanchions fixed in the bodies of the canoes, is laid a boarded platform. All the parts which compose the double canoe are made as strong and light as the nature of the work will admit, and may be immerged in water to the very platform, without being in danger of filling. Nor is it possible, under any circumstance whatever, for them to sink, so long as they hold together. Thus they are not only made vessels of burden, but fit for navigation. They are rigged with one mast, which steps upon the platform, and can easily be raised or taken down; and are sailed with a latteen sail, or triangular one, extended by a long yard, which is a little bent or crooked. The sail is made of mats. On the platform is built a little shed or hut, which screens the crew from the sun and weather, and serves for other purposes. Like the proa, double canoes are navigated either end foremost; any tack being made by shifting the sail without turning the vessel round. Some of the double canoes of Tahiti are sketched in Fig. 817.

Rutherford, who visited and lived among the New Zealanders before the colonization of the English on those islands, describes the canoes of the natives as being somewhat large vessels of the kind. The war-canoes are the property of a particular community, inhabiting a village or district, distinguished from the fishing-boats belonging to individuals. "They are made of the largest sized pine-trees, which generally run from forty to fifty feet long: these are hollowed out, lengthened about eight feet at each end, and raised about two feet on each side. They are built with a figure head; the stern-post extending about ten feet above the stem of the canoe, which is handsomely carved, as well as the figure-head and the whole body of the canoe. The sides are ornamented with pearl-shell, which is let into the carved work, and above that is a row of feathers. On both sides, fore and aft, they have seats in the inside, so that two men can sit abreast. They pull about fifty paddles on each side, and many of them will carry two hundred people. When paddling, the chief stands up and cheers them with a song, to which they all join in chorus. These canoes roll heavily, and go at the rate of seven knots an hour. Their sails are made of straw-mats, in the shape of a lateen sail. They cook in their canoes, but always go on shore to eat. They are frequently known to go three or four hundred miles along the coast." Different forms of New Zealand canoes are sketched in Figs. 810, 811, 812, and 820.

Among the Philippine Islands boats are used which are very sharply built: they are furnished with yards, which serve as balances, in the windward end of which, when the wind blows strongly, the natives place themselves, to counterpoise the effect of the wind on the sail. This contrivance, however, does not always ensure safety, for at times the bamboo which forms the balance-beam breaks, in which case the boat founders. There are also in use small boats called *panques*, made of the hollowed trunk of a tree: these generally will contain but two or three persons, though some of larger size are capable of accommodating from twelve to fifteen: they are worked with oars, and pass lightly through the water. Dampier spoke of some of the islanders' boats as being "much like our deal yalls, but not so big; and they are built with very narrow plank, pinned with wooden pins and some nails. They have also some pretty large boats, which will carry forty or fifty men; these they row with twelve or fifteen oars of a side: they are built much like the small ones, and they are double-banked, that is, two men sitting on one bench."

A mode of making boats or canoes from the solid trunks of trees, as described by the earlier travellers among rude nations, is somewhat as follows:—Before the natives had sufficient intercourse with Europeans to obtain iron, they formed hatchets of stone; and that which they could not effect with such hatchets, they brought about by means of fire. In order to fell a large tree, they applied fire to the lower part of the trunk, preventing the fire from ascending too high by the use of wetted mops or cloths. When the tree was felled and stripped of its branches, preparations were made for hollowing it out, by laying dry branches along it, and setting them on fire. As fast as this fire-wood burned away other was applied, so as to keep up a great heat for a considerable period. The trunk became burned or hollowed out by degrees; and it was part of the operation to keep all the other parts wetted to prevent the undue spread of the flame. The burning being carried as far as was necessary, the shaping of the canoe was finished by a laborious application of stone hatchets and flint knives.

Of boats made from a single tree perhaps the largest are the *ballons* of Siam, if we may credit the statement of the French traveller Turpin, who says that they each accommodate a hundred and fifty rowers. The men row sitting, "their legs crossed like tailors;" an attitude which deprives them of much of their muscular power. The same nation have also long and narrow boats, the planking of which is fastened by ropes made of twigs, and between the joints are placed fragments of a light and porous kind of wood, which, swelling on being wetted, acts as a very efficient caulking.

Symes, in his 'Embassy to Ava,' describes the boats in which his party on one occasion embarked as being "long and narrow, and requiring a good deal of ballast to keep them steady; even with ballast they would have been in constant danger of oversetting, had they not been provided with outriggers, composed of thin boards, or oftener of buoyant bamboos, which make a platform that extends horizontally six or seven feet on the outside of the boat, from stem to stern. Thus secured, the vessel can incline no farther than until the platform touches the surface of the water." On this stage the boatmen ply their oars, or impel the boat forward by poles: it is the place exclusively appropriated to the crew, who sleep on it at night, under the shelter of a sail, or of an awning of mats.

The form of the vessels used on particular seas depends intimately on the nature of the bay or shore near which they ply. This is especially the case opposite Madras, where—whether from the formation of the coast, the narrowing of the bay, the nature of the bottom, the flow of the equatorial current, or from whatever other cause—the sea rages in three distinct and parallel foamy ridges, so violent that no ships can cross them. This is a most unfortunate circumstance for Madras, and greatly limits the commercial advantages which the city might otherwise possess; for the entire communication between the ships and the shore has to be kept up by means of smaller vessels, entailing great delay and discomfort to those who are exposed to the transshipment. There are two kinds of vessels or boats employed upon this service—the *massoolah* and the *catamaran*—both of which are constructed with especial reference to the rough usage to which they are destined.

The *massoolah* is a large, light, flat-bottomed boat, without ribs, keel, or other timbers; the broad planks being secured at the edges with "coire," or line made from the outer fibres of the cocoa-nut, and are filled in between the seams with the same material. Iron is not used in any part of the fabric. By this mode of construction the boat is rendered lithe and buoyant enough to meet the violent shocks which it will have to encounter. It yields to the percussion of the waves, so as, by diminishing the resistance, to be thrown up safely on the beach, without breaking by the concussion. The management of these boats requires great dexterity and experience, the crews being bred from their infancy to this hazardous employment. The massoolah is worked by broad elliptical paddles; and the master chants a wild kind of song, to the cadences of which the rowers keep time, quickening or retarding the motion of the boat as may be necessary to evade or encounter the stroke of the surf. Battling against the successive ridges of surf, the massoolah at length approaches the ship, which is obliged to anchor quite beyond the reach of the surf. The passengers leave the ship, and embark in the massoolah, and the latter returns towards the shore. When they approach the first or outermost ridge of surf, the rowers cease to work, and the boat is dashed with fearful violence over the ridge of surf, after which the rowing recommences. The same ordeal has to be borne three times, until all the three ridges of surf have been passed.

The *catamaran* is a kind of raft, which attends the massoolah to afford aid in the event of the latter being upset, which sometimes occurs. Sometimes, too, the state of the sea is so terrific that not even the massoolahs can venture out; and in such case the catamarans are the only means of maintaining communication between the ships and the shore. They consist of two or three logs of light wood lashed together, the outer ones being seven or eight feet long by six or eight inches in diameter, and the centre are rather longer; one end is rounded off, for facilitating the movement through the water. The boat, or rather raft, is paddled by one or two men, who squat on their knees; and here they will maintain their position for hours together, although the sea may be washing over them all the time; for the surface of the raft is flat, and is level with the water when the men are properly placed in the middle. It is very common for the men to be washed off; but they are expert swimmers, and generally get to their raft again, provided a hungry shark

does not first take a fancy to them. Letters and despatches are often conveyed by these men between the ships and the shore; and in such case the papers are tied up in a kind of skull-cap or turban, and carried in dryness on the heads of the men. These catamaran-men often receive medals and rewards from the government for having saved the lives of persons upset from the massoolahs.

Oriental Vessels and Boats.

From the seas eastward of the Asiastic coast we will transfer our attention to the rivers of that continent. A very remarkable change is now in course of progress in this respect; for wherever English influence is paramount, there the steam-boat is pretty sure to creep in by degrees, and to bring about a system which is as utterly marvellous to the natives as it is important in a civilizing and commercial point of view. To think that the Bengal tribes of the Ganges and the Scikh tribes of the Indus should be indebted to Glasgow and Liverpool for the sight of steam-transit has something pleasant about it, and augurs great results for the future.

The Ganges has many peculiaries about it, and requires some skill in the navigation. It is navigable throughout the year for small boats to the base of the Himalaya range, and during six months in the year for boats of a larger size. The number of boats of various kinds on the river is estimated at upwards of thirty thousand; for the most part crazy and ill-constructed vessels. Those in the districts of Bengal and Chittagong have high heads, with large clumsy rudders suspended by ropes, and worked by helmsmen raised at a great height above the vessel. A sort of passage-boat, called a "panchway," has been likened to a snuffer-tray, with a deck fore and aft, and having in the middle a roof of palm-branches covered with a coarse cloth; the master steers with a long oar, and another man stands in the fore part with a long oar, which he uses for sounding as well as in navigating the boat; six cross-legged rowers work the boat onward with short paddles, which are employed in the same way as oars; and, lastly, a rude sail is used when the wind is favourable. Some of the Ganges boats are sketched in Fig. 833.

Bishop Heber gives a description of a Ganges boat in Bengal, which he characterises as the simplest and rudest of all possible structures. "It is decked over throughout its whole length with bamboo, and on this is erected a low light fabric of bamboo and straw, exactly like a small cottage without a chimney; this is the cabin, baggage-rooms, &c.; here the passengers sit and sleep; and here, if it be intended for a cooking-boat, are one or two ranges of brickwork like English hot-hearths, but not rising more than a few inches above the deck, with small round sugar-loaf holes, like those in a lime-kiln, adapted for dressing victuals with charcoal. As the roof of this apartment is by far too fragile for men to stand or sit on, and as the apartment itself takes up nearly two-thirds of the vessel, upright bamboos are fixed by its side, which support a kind of grating of the same material immediately above the roof, on which, at the height probably of six or eight feet above the surface of the water, the boatmen sit or stand to work the vessel. They have for oars long bamboos with circular boards at the ends, a longer one of the same sort to steer with, a long rough bamboo for a mast, and one and sometimes two sails of a square form (or rather broader above than below), of a very coarse and flimsy canvas. Nothing can seem more clumsy and dangerous than these boats; dangerous I believe they are, but with a fair wind they sail over the water merrily."

One form of Ganges boat is called a "budgerow." It is used as a passage-boat, and is generally accompanied by a luggage-boat, in which the cooking is conducted; while a third boat, smaller than either of the others, and called a "dinghee," keeps up a communication between them in the event of one being fixed on a shoal. Another kind, the "pulwar," is employed for the conveyance of goods, and is both clumsily built and ill-managed. Many of the boats are floating shops; cargoes of glass, cutlery, perfumes, &c. being carried as high up as the stream will admit, and sold to any purchasers who may be met with on the way. The whole system of internal navigation of India is, however, now undergoing a mighty change by the introduction of steam; some of the towns on the upper course of the Ganges are practically—in respect to time, fatigue, discomfort, freightage, and insurance—as far from Calcutta as Calcutta is from England, when the navigation is conducted in the boats of the country; but by the introduction of steam-boats having a burden of about sixty tons, and drawing only two feet of water, a change has been wrought which promises to be of the highest importance to the welfare of India. In Singapore, one of the East India Company's possessions, the natives employ the curious flat-sterned vessels seen in Fig. 835.

The Japanese vessels, according to Kaempfer, are built either of fir or of cedar, and are of various kinds, according as they are intended to navigate the seas or the rivers. The sea-vessels are built both for sailing and for rowing; they run tapering from the middle towards the stem, and both ends of the keel stand out of the water considerably. The stern is broad and flat; and the body of the hull below the water level slopes off nearly in a straight line to the keel. The deck is somewhat raised towards the stern, and consists only of deal boards laid down without any fastening; it rises but little above the surface of the water when the vessel is laden. Over the deck is a flat-roofed cabin, extending nearly from end to end, and divided into compartments for various purposes: the roof forms an upper deck, on which the crew find shelter during bad weather under a covering of sails or matting. These vessels have but one mast and one sail, the latter made of hemp. When the wind fails, thirty or forty rowers are employed to work the vessel, the rowers' benches being near the stern; they row to the cadence of a kind of song, and work their oars much more perpendicularly than is customary in English boats. The oars are somewhat bent, with a moveable joint in the middle, so formed as to facilitate the lifting of the oar out of the water after the stroke is made. In some of the vessels the rudder is capable of being wound up out of the water when the voyage is ended.

The boats and vessels built by the Chinese have many peculiarities about them, both in shape and in internal arrangements; and in one respect superstition is brought to bear strangely on the matter. All the vessels are divided into two classes—those with eyes and those without eyes. The former have always a large eye painted on each side of the bows, and they include the larger *junks* or ships which navigate the Chinese seas; the eye being supposed to represent some mysterious power of seeing and avoiding danger.

The general materials used in building the boats are oak and teak; very little metal is used in any part; indeed so little, that the bolts, the knees, the stanchions, and even the anchors, are generally made of wood. The seams are all stopped with a substance called "chinam," which is a kind of mortar or putty obtained from the chinam-tree; it becomes as hard as stone when in the seams, and thereby secures them very closely. The deck-planks are never secured, although well prepared and dove-tailed; they are made to take up at pleasure, as a means of affording access to the utensils and luggage stored below. The masts are of bamboo; and the sails, made of rattan sown together, are fastened to bamboo-joints running parallel, so that they may open in the manner of a fan, or may be reefed at pleasure by closing any of the joints. The rudder is large and unwieldy.

The boats on the Chinese rivers are of many different denominations, according to the purpose for which they are used. One kind is called the *hwa-chow*, or *flower-boat* (Fig. 821). These are generally occupied by the wealthy classes on summer evenings; and seem to be employed more as a means of being on the water than for making progress, for they are often moored in rows. Another kind, called a *sanpan* (Fig. 822), is generally managed by females, who row by means of a scull or oar. Sometimes there is an oar used towards the head of the boat, suspended with a loop from a strong peg at the side of the boat. The interior accommodations of the flower-boats, and some other kinds, are much better than a first glance would seem to indicate. Large coverings or awnings are raised upon the deck, made of bamboo and rattan; and they are not only quite impervious to rain and sun while in use, but, being made in several divisions, they can be removed partially or wholly, according to the state of the weather. The interiors are very tasteful, being beautifully painted, and carpeted with a kind of floor-cloth. In the larger kind of pleasure-boats, such as Fig. 823, intended for the accommodation of mandarins and distinguished persons, there are latticed windows to admit light into the interior; and these, being decked with shrubs and flowers, give the whole an elegant appearance. Mr. Davis, speaking of one of these boats, says, "The travelling-barges used by mandarins and opulent persons afford a degree of comfort and accommodation quite unknown in boats of the same description elsewhere; but it must be repeated that *speed* is a quality which they do not possess. The roof is not less than seven or eight feet in height, and the principal accommodations consist of an ante-room at the head for servants, a sitting-room about the centre of the boat, and a sleeping-apartment and closet abaft. All the cooking goes on upon the high overhanging stern, where the crew also are accommodated. There are gangways of boards on each side of the vessel, which serve for poling it along the shallows, by means of very long and light bamboos, and which also allow of the servants and crew passing from head to stern without incommoding the inmates. The better boats are very well lit with glass windows at the sides, or by the thin interior laminæ of oyster-shells. Others have transparent paper or gauze, on which are painted flowers, birds, and other devices; while the partitions or bulkheads of the apartments are varnished and gilded. The decks or floors of the cabins remove in square compartments, and admit of all the baggage being stowed away in the hold. Everything in their river boats is kept remarkably clean, and this habit presents a strong contrast to their general neglect of cleanliness in their houses on shore, which have not the same ready access to water, and are besides often very ill drained. In short, their travelling-barges are as much superior to the crank and rickety budgerows of India as our European ships are to the sea-junks of the Chinese, who seem to have reserved all their ingenuity for their river craft, and to have afforded as little encouragement as possible to maritime or foreign adventure."

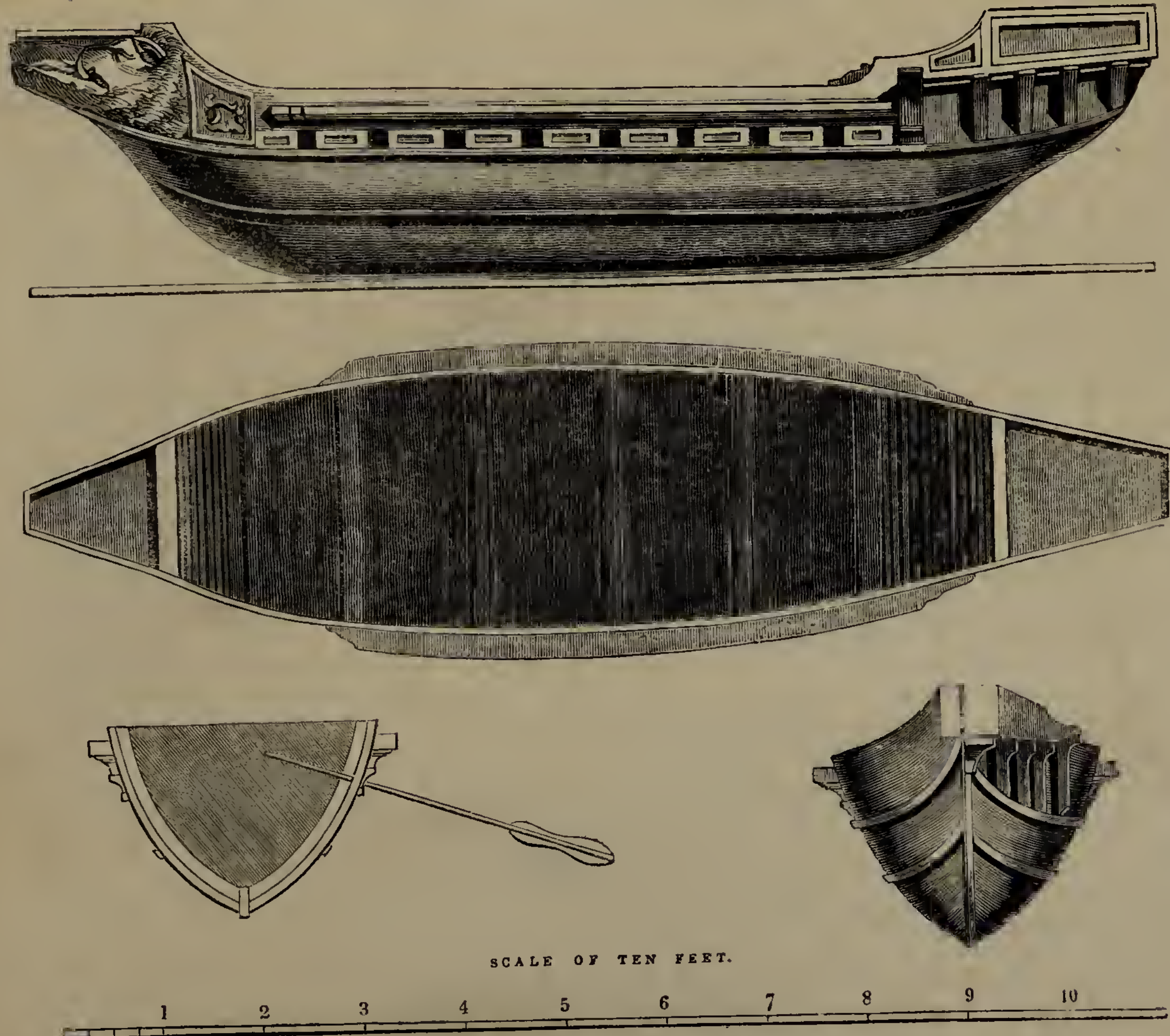
The *junks* here spoken of (Figs. 824, 825) have a shape not much unlike that of a Chinese shoe. In lieu of pitch, the planks are caulked with a putty composed of burnt gypsum and oil, mixed sometimes with bamboo shavings. They have flat unwieldy sails of matting. There is no keel whatever, the bottom being flat; and although the general construction is adverse to speed, and even to safety, the inveterate prejudices of the natives prevent them from introducing improvements. As long as the junks confine themselves to the neighbourhood of the coast, their course is pretty certain; they generally stand boldly across between the most prominent headlands, and are guided along the whole line of coast by a tolerably accurate directory, in which are noted the harbours, currents, shoals, and other particulars. The Chinese seamen are acquainted with the use of the compass, and avail themselves of it when necessary.

Many of these trading-junks are owned or hired by a sort of copartnery, every partner having the privilege of putting a certain quantity of goods on board for sale or barter at any port where they may touch. The chief object of those on board being trade, the navigation of the vessel is made a subordinate matter, and the captain is by no means so influential a person as he generally is in other countries. The crew exercise full control over the vessel, and oppose every measure which they deem injurious to their own interest; so that the captain and pilot are frequently obliged to submit to them. In time of danger the men often lose all courage, and their indecision, with the confusion that attends the absence of discipline, not unfrequently proves the destruction of the junk.

Another kind of Chinese boat is the *tsau-chuen*, or cargo-boat, used on the great canal for the conveyance of grain. Boats of this kind (Fig. 818) are very numerous, there being said to be no fewer than one thousand of them belonging to the government. They stand very high out of the water, and have a burden of about a hundred tons each. The *chop-boats* (Fig. 826) are a kind employed as lighters in transporting cargoes up and down the rivers, to and from ships anchored in the bays. There are also mandarin-boats, or revenue cutters, which, besides having masts and sails, are rowed by thirty-two oars, and are therefore by far the swiftest of all the boats. Each of these contains about a hundred soldiers, whose round shields are placed round the outside gunwale in regular order; there is a poop at the hinder end, covered with a handsome rattan awning, and appropriated to the mandarin and officers.

But perhaps, of all others, the boats most characteristic of the Chinese people are those on which many thousands of the population live and sleep. There are said to be about forty thousand *sanpans*, or small family boats, on the river near Canton, containing a population of two hundred thousand persons. These persons make the boat their home; the husband finding work on shore during the day, and the wife taking care of the floating habitation, or perhaps earning a trifle by conveying passengers from place to place. It is one particular tribe who inhabit these boats, and they are licensed by the government. The boats are from fifteen to twenty feet in length, and are kept remarkably clean. Nearly all the above varieties of boats are sketched in Fig. 827.

Returning again towards the west we find, on the river Toombudra, in Hindostan, a curious mode of making basket-boats. They are circular, and of various sizes, from three to fifteen feet in diameter, but very shallow, and yet some of them can contain thirty persons. In making them, a number of pieces of split bamboo are laid on the ground, crossing each other near the centre, and there fastened with thongs; the ends of the bamboos are then elevated by several persons, and fixed asunder at proper distances by means of stakes, in which position they are bound by other long slips of bamboo; the latter are introduced alternately over and under the pieces first crossed, and tied at the intersections to preserve the shape. This being completed, beginning from the bottom towards the centre, the parts above the intended height or depth of the boat are cut off, and it is covered with half-dressed hides fastened together with thongs. These simple basket-boats are so easy of construction, that it is said one may be made by six men in as many hours, and the two principal materials used—hides and bamboo—are always at hand. The boats are navigated either by paddles where the water is deep, or are pushed over a shallow bottom with long poles; and the passengers within are safely transported, being kept dry by planks and pieces of wood at the bottom. On the river Krishna, in the same country, there are basket-boats employed about



841.—Elevation, Plan, Section, and Stern of a Roman Galley.

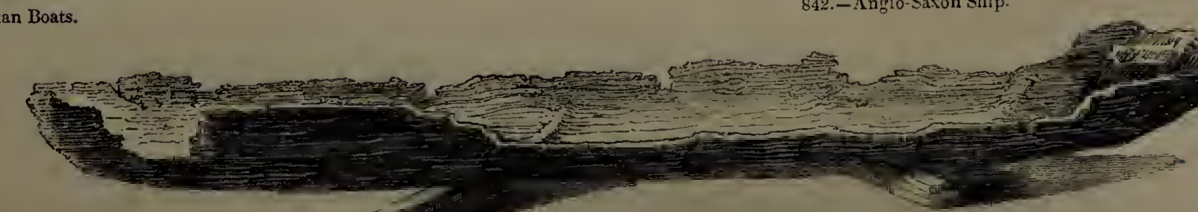
838—Venetian Gondola, with a single Rower

843.—Anglo-Saxon Ship. (From an Illuminated MS.)

839.—Neapolitan Boats.

842.—Anglo-Saxon Ship.

Foreshortened View.



Side View

840.—Ancient British Canoe, dug out of a Marsh in Sussex.

845.—Coracle, or Wicker Boat of the River Wye.

844.—Ancient British Coracles or Canoes.

847.—War-Galleys of the Fifteenth Century. (From an Illuminated MS.)

846.—Anglo-Norman Ship. (From the Bayeux Tapestry.)

848.—Ships of the Time of Richard II. (From an Illuminated MS.)

849.—Thames State Barge, temp. Richard II.

twelve feet in diameter by four deep; whole armies, among the tribes of Hindostan, have been transported by means of boats of this kind, and even heavy artillery has been similarly conveyed. It is a remarkable instance of the fixity of habits in the East, that Herodotus alludes to the use of such basket-boats on the Indus and the Euphrates more than two thousand years ago: they are used at the present day on some parts of the Indus, and are about seven feet in diameter.

Mr. Lane, speaking of the interior navigation of Egypt, says:—"The navigation of the Nile employs a great number of the natives of Egypt. The boatmen of the Nile are mostly strong, muscular men. They undergo severe labour in rowing, poling, and towing; but are very cheerful, and often the most so when they are most occupied, for then they frequently amuse themselves by singing. In consequence of the continual changes which take place in the bed of the Nile, the most experienced pilot is liable frequently to run his vessel aground; on such an occurrence it is often necessary for the crew to descend into the water, to shove off the boats with their backs and shoulders. On account of their being so liable to run aground, the boats of the Nile are generally made to draw rather more water at the head than at the stern, and hence the rudder is necessarily very wide. The better kind of boats used on the Nile, which are very numerous, are of a simple but elegant form; mostly between thirty and forty feet in length, with two masts, two large triangular sails, and a cabin next the stern, generally about four feet high, and occupying about a fourth or a third of the length of the boat. In most of these boats the cabin is divided into two or more apartments. Sudden whirlwinds and squalls being very frequent on the Nile, a boatman is usually employed to hold the sheet in his hand, that he may be able to let it fly at a moment's notice." Some of the Nile boats are sketched in Figs. 819, 836.

Sir J. G. Wilkinson gives rather a fuller account of the Nile-boats; dividing them into the "djerm," the "maádil," the "aggub," the "maash," the "dahabeeh," the "cangia," the "kyas," the "sandal," the "seféuce," the "garib," and the "maadéch." Of these, some are used only during the time of inundation, being large boats, thirty or forty feet in length by ten or twelve in width, with two masts and lateen sails; while the others are mostly small open boats. The "djerm" and the "maádil" carry corn up and down the Nile; the "aggub" carries stone; the "sandal" is a sort of ship's boat; the "garib" is a fishing-boat; the "maadéch" a ferry-boat. The "maash," the "dahabeeh," and the "cangia," are three forms of passenger-boats, usually hired by Europeans in making the voyage from Alexandria to Cairo; the larger ones having two cabins, but the smaller ones only a single cabin; and many travellers cause an awning to be fitted up in front of the cabin, so as to enjoy what breeze there may be without being exposed to the intense heat of the sun.

Vessels and Canoes in the American Rivers.

A curious kind of a canoe, called a *balsa*, is made by the natives on the banks of the river Gayaquil in South America. It is a kind of raft made of logs of trees laid side by side; the logs so employed being of a white, light, spongy sort of wood. The logs, eight or ten in number, are fastened together by withies, with which the cross-logs are also lashed to them. The thickest log of the balsa is placed so as to extend farther than the others; at the stern end another log is lashed to this on each side, and others to these, until the intended number is completed: the large log thus serves as a centre or support for the others. The large balsas usually carry about twenty-five tons without endangering the cargo, and by yielding to the swelling and sinking of the waves, accommodating their position to the state of the watery bed beneath, they keep tolerably free from flooding. They work and ply to windward like a keeled vessel, and keep their course before the wind very accurately; this is effected by the use of large planks called *guares*, ten or twelve feet long, which are set up vertically both at the stem and stern; by moving these boards in different directions, as occasion may require, the balsa is guided with considerable accuracy.

A fishing tribe on the banks of the Columbia, in Oregon, make canoes fifty feet in length out of a single tree of fir or of white cedar, and capable of carrying thirty persons each. They have cross-pieces running from side to side about three inches thick, and the gunwale of the canoe curves outward, so as to throw off the surges of the water. The Indians, in managing these canoes, kneel two and two along the bottom, sitting on their heels, and wielding paddles four or five feet long, while one sits at the stern and steers with a similar paddle. Singular dexterity is said to be shown by the Indians in the management of these canoes, for if a surge should throw the canoe on one side and endanger it, those to windward lean over the upper gunwale, thrust their paddles deep into the water, and seem to force the waves under the canoe, thereby restoring its equilibrium and at the same time urging it rapidly forward.

Lahontan, who visited Canada in 1683, gave a tolerably minute account of the kind of canoes made and used in that country at that time; and the account accords pretty nearly with those given by later travellers. He describes the canoes as varying in size from those which will contain only two persons to those which will afford accommodation for fourteen. "The largest sort are safe and steady when they are made of the bark of the birch-tree, which comes off with hot water in the winter-time. The greatest trees afford the best barks for canoes; but oftentimes the bark of one tree is not sufficient. The bottom of the boat is all of one piece, to which the sides are so artfully sewed by the savages that the whole boat appears as one continued bark. They are trimmed and strengthened with wicker wreath and ribs of cedar-wood, which are about as light as cork; the wreaths are as thick as a crown piece, but the bark has the thickness of two crowns, and the ribs are as thick as three. On the two sides of the boat there run from one end to the other two principal head-bars, in which the ends of the ribs are encased, and in which the spars are made fast that run across the boat and keep it compact. These boats are twenty inches in depth, that is, from the upper edge to the platform of the ribs. Their length extends to twenty-eight feet, and the width at the middle rib is computed to be four feet and a half. They are very convenient on account of their extreme lightness, and the drawing of very little water; but at the same time their brittle and tender fabric is an argument of an equivalent inconvenience; for if they do but touch or grate upon stone or sand, the cracks of the bark fly open, upon which the water gets in, and spoils the provisions and merchandise: every day there is some new chink or seam to be gummed over. At night they are always unloaded and carried on shore, where they are made fast with pegs, lest the wind should blow them away; for they are so light that two men carry them on their shoulders with ease. This conveniency of lightness and easy carriage renders them very serviceable in the rivers of Canada, which are full of cataracts, waterfalls, and currents; for in these rivers we are obliged either to transport them overland where such obstructions happen, or else to tow them along where the current is not over rapid and the shore is accessible."

The same writer proceeds to state that such boats are of no use in the navigation of the Canadian lakes, where they would soon be overset by the waves. Small sails are carried when the wind is low, but the extreme lightness of the canoes renders such a plan perilous under any other circumstances. The men stand, sit, or kneel while rowing, according as they have to stem a current, to float along smooth water, or to descend the rapids; the oars employed being made of maple-wood. The canoes have neither stem nor stern, being run to a point at both ends; they have no keels, and have neither nails nor pegs in their whole composition.

The boats which Sir Alexander Mackenzie, at a later period, described as being used by the Canadian voyageurs in conducting the fur-trade, were of such a kind that they could be carried by six men each from lake to lake, or from river to river, according to the exigencies of the navigation. When going on the journey towards the interior, each canoe contained eight or ten men, with their baggage; together with sixty-five packages of goods, six hundredweight of biscuit, two hundredweight of pork, three bushels of peas, for the men's provisions; two oil-cloths to cover the goods, a sail, &c.; an axe, a towing-line, a kettle, and a sponge to bail out the water, with a quantity of gum, bark, and watape, to repair the vessel. "An European," Sir Alexander remarks, "on seeing one of these slender vessels thus laden, heaped up, and sunk with her gunwale within six inches of the water, would think his fate inevitable in such a boat, when he reflected on the nature of her voyage; but the Canadians are so expert that few accidents happen."

The manufacture of boats from elm-bark is conducted in a very ingenious way in some parts of North America. An elm-tree is selected, which is thick, tall, smooth in the bark, and having but few branches. The tree is cut down, and in the process of cutting great care is taken to prevent the bark from being hurt by falling against other trees or against the ground; with this view the bark is sometimes scaled from the tree before the latter is felled. The bark is split on one side in a straight line along the tree, to the intended length of the boat; and it is at the same time carefully cut from the stem a little way on both sides of the slit, to make it separate more easily. The bark is then carefully peeled off, particular care being taken not to make any holes in it; and, when wholly separated, it is spread on the ground in a smooth place, with the inner side downwards, and the rough outer surface uppermost. Logs of wood or stone are put upon it, to press it down; and the sides of the bark are gently bent upwards, in order to form the sides of the boat; some sticks are fixed into the ground, at a distance of three or four feet apart, following the curve line which the boat is afterwards to present, and these are intended to aid in fixing the ribs of the boat. The ribs are made of thick branches of hiccory, tough and pliable; the branches are cut into several flat pieces, about an inch thick, and bent into the form which the ribs require, according to the varying width of the boat. They are then applied to the bark, at a distance of eight or ten inches apart, to form the framework of the forthcoming boat. The edge of the boat on each side is made of two thin poles, of the length of the boat, so adjusted that the bark can be brought up between them, and sewed round them with thread made of some fibrous root.

The commencement of covering the framework is made by bringing up the ends of the ribs between the two poles on each side, then bringing up the edges of the bark, as just described, and then fastening the poles to each other and to the other parts, so as to form the contour of the boat. To prevent the widening of the boat at the top three or four transverse boards are put across it, from one edge to the other, at a distance of thirty or forty inches apart; these boards are commonly made of hiccory, on account of its toughness and flexibility; their extremities are put through the bark on both sides, just below the poles, and they are bent up above those poles. As the bark at the two ends of the boat cannot be put so close together as to keep out the water, the crevices are stopped up with the crushed or powdered bark of the red elm, which in that state bears a good deal of resemblance to oakum. Some pieces of bark are put upon the ribs in the boat, without which the foot would easily break through the thin and weak bark which forms the bottom of the boat; and, for the further security of this, thin boards are commonly laid along the bottom. By this arrangement of the boat-covering the smooth inner surface of the bark becomes the outer surface of the boat, for which it is fitted by the facility with which its smooth surface will glide through the water. A boat of this kind is generally made in a day or two; and so fragile is it, that great care is necessary on the part of any one embarking in it, for a sudden leap into the boat would very probably lead to a hole being burst through the bottom. Yet such boats are very convenient for the persons and in the districts where this mode of construction is adopted.

Many of the Esquimaux tribes, deprived of the bark which is available in more southern regions, avail themselves of the skins of animals in making boats or canoes. The outside of some of the Esquimaux boats consists entirely of skins, the hair of which has been taken off; the inner side of the skin is turned outward, so as to present an extremely smooth surface to the water. In the inside of the boat are placed two or three thin boards, which give a kind of form to it. The boat is quite covered with skins at the top, except near one end, where a hole is left large enough for a man to sit and row in, and keep his thighs and legs under the deck of skins; this hole is surrounded with wood, on which a soft folded skin is fastened, with straps at its upper end. When one of the natives uses such a boat as this, he puts his legs and thighs under the deck, sits down on the bottom of the boat, draws the skin round his body, and fastens it well with straps. The waves may then beat over the boat with considerable violence, and yet no water shall enter it. The boat is navigated with an oar having a paddle or broad palm at each end.

Some of the Greenlanders have boats of a larger and stronger kind, though perhaps not so swift. They are made of wood, fastened together by cross bars or boards, joined with thin strips of whalebone, ranged equidistant. They are lined with the skins of seals, well sewn together with animal fibres instead of thread, and the joints well greased to prevent water from penetrating. These canoes are of different sizes, some being capable of carrying twenty persons, with their arms and baggage: indeed it is in such boats as these that the Greenlanders go out to fish. These boats have sails made from the intestines of the whale, split and dried, and sewn one to the other.

The Laplanders, another snow-girt people, make very tolerable boats of fir, joined together by thread of rein-deer skin. Sometimes they are fastened with hempen thread, and sometimes with cords of birch-bark, or with fibres of the fir-root. Boats of a very similar kind are made by the natives on the shore of the Gulf of Bothnia. Maupertuis, who went to that region to measure an arc of the meridian in the last century, says that the boats are so light and so flexible that, notwithstanding they continually strike against the stones with which the rivers are full, borne by the whole violence of the torrent, they bear the shock without injury. "It affords a sight," he says, "terrible for those unaccustomed to it, and astonishing to all, to behold this frail machine in the midst of a cataract, the noise of which is deafening, carried away by a torrent of waves, froth, and stones; sometimes borne up aloft, and at others lost amid the waves; one dauntless Fin steering it with an oar, while two others row with all their might, to escape the following waves, that threaten to overwhelm them; at such times the keel is often above the water, and only supported by one extremity pressing on a wave, which sinks at every instant." Slight varieties are observable among the boats in different parts of this region, but they are, for the most part, extremely light in their structure. Thus, one kind has ribs covered with

thin planks of deal, joined at the edges with the sinews of the rein-deer. Most of the boats are furnished with a mast, which is raised and lowered by three ropes made of rein-deer sinew or of root-fibres, and on which a sail may be hoisted when necessary. Sometimes the hardy boatmen make use of a very primitive substitute for a sail, being nothing more than a small fir-tree, with its branches on, held upright in the middle of the boat.

Vessels and Boats of the Mediterranean States.

The navies of most European countries are now so much alike, in the general form and construction of the ships, that a description of a large English ship would include nearly all the features observable in any of the others. Yet there are—and were so more particularly in past days—certain characteristics in the smaller vessels of some countries which render them worthy of a little attention.

Perhaps the most striking of all these is the *gondola* of Venice (Fig. 838), a kind of vessel, taken in connexion with the place where it is used, which has called forth many a stanza from Shakspere, Byron, Rogers, and other poets. The gondola is the "omnibus" of Venice. The city is intersected by so many canals, forming what may correctly be termed marine streets, that the inhabitants maintain communication between one place and another by means of gondolas rowed along the canals; and as there are water-gates, or stairs, or terraces from most of the best houses, the facility of access is very great.

The gondola is, in general, about thirty feet long by five broad, affording accommodation for six passengers and two rowers. Some, however, are of smaller size, and are rowed by one person alone. The bottom of the boat is flat, and the sides slope away considerably, especially towards the stern, which rises high out of the water when the boat is empty. The seats for the passengers have a tilt or awning over them, and are placed rather nearer to the stern than to the head; the tilt is light and elegant, and removable at pleasure: it is formed of framework, covered with black cloth, ornamented with tufts of the same colour, and provided with window-openings and curtains. The head is furnished with a flat iron beak or prow; and at the stern is another beak made of wood, not quite so elevated as the other. At one period the gondolas of Venice used to exhibit a dazzling display of colours, but they are now invariably painted black, which gives them a sombreness of appearance somewhat at variance with the gay scenes depicted by early poets and writers. So much of the internal pleasure-traffic of the Venetians is carried on by means of these gondoliers, that the head gondolier is to a Venetian nobleman what the head coachman is to an English one.

Where the gondola is double-oared, the head gondolier takes his station in front of the company, and on the right side of the boat; the other one placing himself nearer the stern, and on the left hand side of the boat. The rowers stand so near the extreme edges of the boat that the occupation seems a somewhat perilous one; but accidents seldom happen to the men; they balance themselves with great ease. The oars are made of light fir, shaped more like a paddle than like an English oar; they are not used with rowlocks on the side of the boat, but are merely pressed against a bent piece of wood as a fulcrum. The gondoliers, when about to turn a corner from one canal into another, give a sort of musical cry or signal, which is said to be by no means disagreeable. So numerous were these gondoliers when Venice was in its prime, and so necessary their services, that they formed a body more important than mere "watermen" usually are. They have been long celebrated for the songs and scraps of verses, taken from Tasso and other poets, which they sing while gliding over the water. Lord Byron, in a note to the fourth canto of 'Childe Harold,' speaks of this kind of singing as suiting "particularly well with an idle solitary mariner, lying at length in his vessel, at rest on one of these canals, waiting for his company or for a fare, the tiresomeness of which situation is somewhat relieved by the songs and poetical stories he has in memory. He often raises his voice as loud as he can, which extends itself to a vast distance over the tranquil mirror; and as all is still around, he is, as it were, in a solitude in the midst of a large and populous town. Here is no rattling of carriages, no noise of foot-passengers: a silent gondola glides now and then by him, of which the splashings of the oars are scarcely to be heard. At a distance he hears another, perhaps utterly unknown to him. Melody and verse immediately attach the two strangers; he becomes the responsive echo to the former, and exerts himself to be heard as he had heard the other. By a tacit convention they alternate verse for verse: though the song should last the whole night through they entertain themselves without fatigue, and the hearers, who are passing between the two, take part in the amusement."

In times gone by, when Spain held a prouder position among the nations of Europe than she now does, her *galleons* were important vessels. Some of these were but little less in size than our first rate men-of-war, being calculated to contain twelve hundred men; the smallest being able to accommodate three hundred. They were engaged in maintaining the intercourse between the Spanish possessions in the Philippine Islands and those on the coast of America; so that their voyage embraced nearly the whole extent of the Pacific Ocean. From Manilla (the chief port of the Philippines) the galleons used to take spices, silks, calicoes, and various fancy articles, the produce of China and India; while from America they took silver, cochineal, and other articles of American produce. The whole voyage from Manilla to America and back again took up nearly a year. All the galleons were ships of war, and went on the king's account; but they were so laden with merchandise that in case of attack they found it difficult to defend themselves; and hence it arose that during the time of war the capture of a "Spanish galleon" was a matter eagerly looked forward to. The homeward voyage to Spain was the one most tempting to an enemy; for the galleons had then a vast treasure in gold, silver, pearls, emeralds, and other gems, costly woods and furs, cochineal, indigo, and other produce of America and Asia.

The name "galleon" is evidently derived from the ancient "galley," and so likewise is the "galleasse," a kind of vessel employed by the Venetians when at the height of their power. A galleasse was as much as a hundred and sixty feet in length by thirty-two in width; it was furnished with three masts and thirty-two banks of oars; each bank containing two oars, and every oar being managed by six or seven slaves, who were usually chained to it. In different parts of the vessel were placed small batteries of cannon. The complement for one of these was as much as a thousand men. As they drew but little water, the galleasses were used for making a descent on an enemy's coast; and on account of their oars, they had often the advantage of ships of war in light winds or calms, by cannonading the latter near the surface of the water. Another kind, called "half-galleys," were smaller than the former, being about a hundred and twenty feet long by eighteen broad; they had two masts, two large lateen sails, and twenty-five banks of oars. A still smaller variety, but similar to the others in general arrangement, was the "quarter-galley." The galleys with a great number of oars are still to be met with on the shores of the Mediterranean; but they are rapidly giving way to sails and steam.

Along the northern coast of Africa, from Egypt to the Straits of Gibraltar, are a number of Moorish nations who for ages infested the Mediterranean with pirate vessels: a system which was never efficiently checked until the taking of Algiers by Lord Exmouth, in 1816. The vessels employed by the Moors were (for French intervention has greatly altered the state of things) of several kinds, comprising the *galley*, the *xebec*, the *felucca*, and the *saicque*. The galley, a ship of war, like those of the northern Mediterranean shores, was lofty, especially at the hinder end; long and narrow, and contrived with every attention to sailing in light winds and smooth water, so as to be able to attack other ships which might be then in the least efficient state. Of the form of galley called the xebec, Mr. Charnock, writing in the early part of the present century, said:—"It were scarcely possible, perhaps, for the most refined improvement to give, considering the peculiar occupation in which the xebec is employed, any additional advantage to the structure as it now stands, and which has, in all probability, undergone less alteration during the last two centuries, which certainly carries it back to a more infantine state, than any other class of vessels which either does now or ever did exist. Founded on the principle of that galley by which Rome in the zenith of prosperity extended its conquests, little alteration, and that only as far as actual necessity required, was introduced into the present vessel bearing the same name, when the invention of cannon and the use of gunpowder caused, in other countries, so great a revolution with respect to the principles of marine architecture."

The *felucca* is a little vessel with from ten to sixteen banks of oars, without a deck, and used by the Moors as cruisers: it has this peculiarity, that the rudder may be applied either to the head or the stern, there being arrangements at both ends adapted to receive it. A *saicque* is employed as a merchant vessel: it has square-sails on the middle-mast; and the mast is so lofty as to make the vessel visible for a great distance: with a favourable wind it goes with great swiftness; but the contour is said to be such as to prevent it from sailing with a side-wind. The *polacca*, the *barque*, the *barchetta*, or little barque—all are varieties of vessel intermediate between the galley and the modern ship, and all are known in the Mediterranean, both on the Italian shores to the north and the Moorish shores to the south. And the same may be said in respect to Greece and Turkey; for there is sufficient similarity of feeling and of pursuit between the Moors and the Turks on the one hand, and between the Italians and the Greeks on the other, to lead to a similarity of usages in ship-building.

The rivers which flow into the Mediterranean, and other European rivers which find an outlet elsewhere, all have their peculiarities in respect to the boats and the system of navigation adopted; each one exhibiting its own features according to the depth and turnings of the river, the nature of the traffic, and the general habits and employments of the people. Thus we may easily see how different are the vessels sketched in Figs. 837 and 839. In the Rhône, the Loire, and the Seine, according as grain, or wine, or fire-wood, or general merchandise is to be conveyed, so do the forms of boats differ. In Spain there appears to be less internal navigation than in almost any other country in Europe. Italy and Switzerland are not largely supplied with navigable rivers; the northern states of Europe employ ships and barges somewhat like our own; while the Rhine is every year becoming more and more a steam-boat river.

As a general illustration of many different forms of river-navigation, we may take the Danube. In Murray's 'Handbook for Southern Germany' it is remarked that though the Danube is the second river of Europe as to size, "yet the navigation of it bears no proportion to its rank and size. This is owing to the rapidity of its current, the obstructions in its channel, but more than all to the absence of a circulating commerce along its banks, and the want of enterprise on the part of the inhabitants to use it as an outlet for the produce of the countries which it traverses. The vessels hitherto committed to it, previous to 1830, when a steamer was first launched on the river at Vienna, consist almost exclusively of barges of unpainted planks, slightly fastened together, so as to hold together in a descending voyage, but rarely capable of ascending, and valued only as so much planking, to be broken up on reaching their destination. Being intended almost exclusively for the conveyance of merchandise, the accommodation of travellers is but little studied on the Danube, and the number of those who may be called tourists or travellers for pleasure has been proportionately small."

The descent of the Danube is effected in different ways, according to the means of the travellers. The cheapest mode is by *rafts*. A description was given in a former page of the mode of floating timber down the Danube in enormous rafts: a passage on these rafts is sometimes taken by travellers; but it is the slowest and most comfortless of all the means of conveyance. Another mode is by *barges*. These are described as being unwieldy fabrics of rough planks, flat-bottomed, without a keel, but having a roof over the centre. These barges are steered by paddles formed of the stem of a tree, with a board nailed to one end, suspended over the deck by thongs, while the broad end immersed in the water serves to keep them within the influence of the current, to which they are more indebted for progressive motion than to the boatmen's oars. Another mode is by *passage-boats*, called ordinari, which make the passage on fixed days. There is a hut of rude planks run up in the centre of the vessel; but this is intended rather to protect the merchandise from wet than to accommodate passengers: "A small part only is allotted to their use, which they are often compelled to share with very low company, among sacks, casks, and bales. As the vessel has no deck, there is no space to move about; and they must content themselves either to recline upon its sloping roof, or to sit confined in the little hole of a cabin at one end. The passenger must be prepared at times for most vexatious delays arising from mists, which towards autumn lie very thick on the river, and seldom rise until the sun is high in the heavens; but, above all, from winds. A very slight gust is a sufficient excuse for the unskilful and timid boatman on the Danube to make for the shore, where he often lies moored for days together."

A somewhat better kind of boat is the *private boat*, hired for the journey, and having two or three boatmen, according to the number of travellers. Even these, however, are very clumsy specimens of boat-building; they have a flat bottom, and resemble a large punt more than anything else. Vessels with sails are scarcely known on the Danube, except near its mouth; and steam-boats are the only other mode of water conveyance. The steam-boat system of Austria is peculiar. Two Englishmen, named Andrews and Pritchard, aided by two or three Austrian noblemen, and the bankers of Vienna, succeeded in forming a company about fifteen years ago, which received from the government a charter conferring the exclusive privilege of navigating the Danube and all other Austrian rivers, for a period of fifteen years, afterwards extended to twenty-five. All the chief princes and nobles became shareholders in the company, and the system by degrees assumed a respectable position. One regular trip or voyage is from Vienna to Constantinople, through the Danube and the Black Sea; and this occupies from ten to seventeen days, the return voyage against the stream being of double this duration. The sand-banks of the river are so numerous and intricate, that it is said to be no uncommon occurrence for a steamer to stick upon one for eight or ten hours, until it can be lightened by the entire removal of the cargo. The steamers are obliged to lie-to in the dark; but during the long days of summer, and in clear moonlight nights, they continue the voyage.

852.—The Sovereign of the Seas, built by Charles I.

850.—Ships of War of the Fifteenth Century. (From Illuminated MS.)

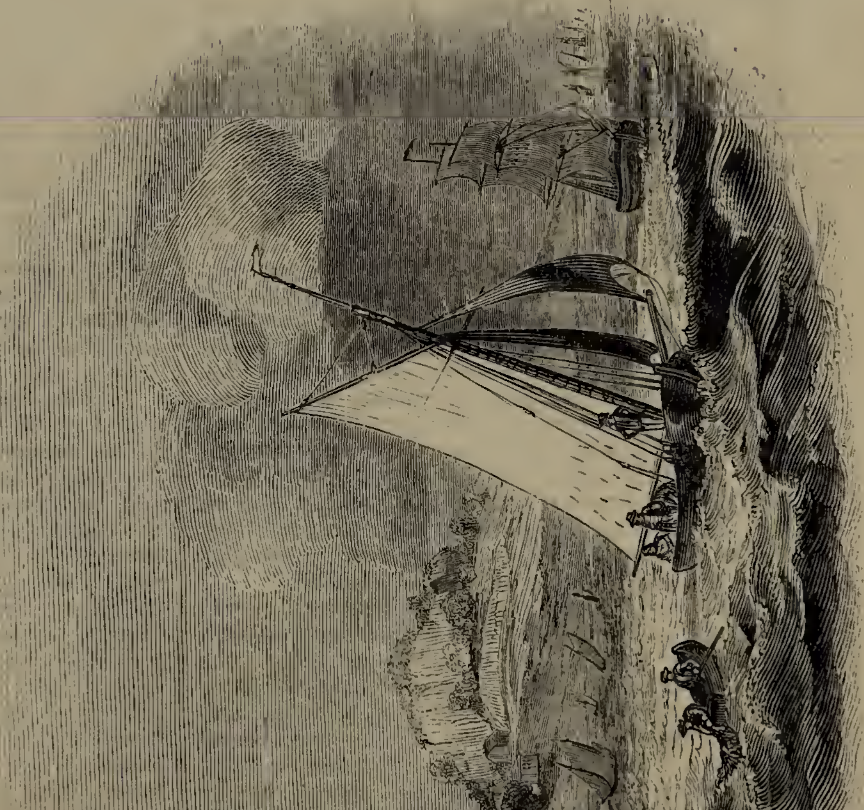
851.—The Henri Grace-à-Dieu, built by Henry VIII.

853.—Ship of War, as represented on a Medal in Charles II.'s reign.)

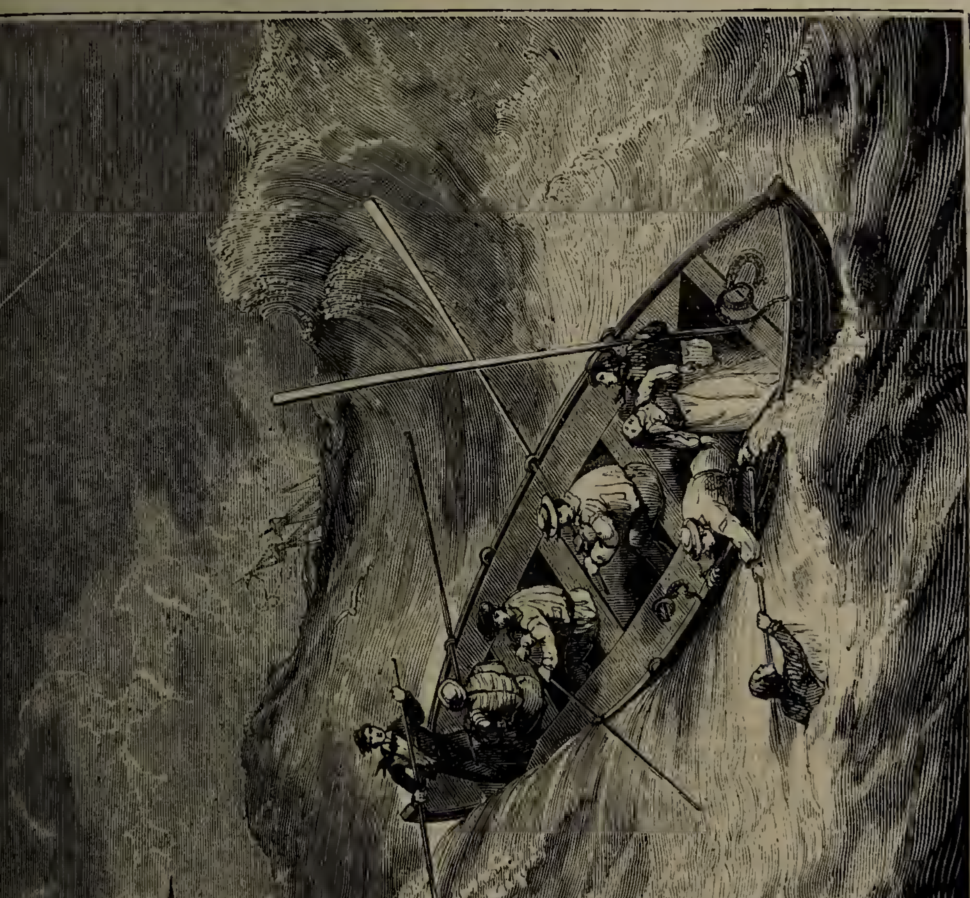
854.—Thames Steamers.

855.—The British Queen, Steam-Ship.

856.—Thames Barges, near Walton.



857.—Thames Fishing-boats, off Purfleet.



858.—The Life-boat in a Storm.

859.—Preparing to Launch the life-boat.

PROGRESS OF ENGLISH SHIPS AND SHIP-BUILDING.

AFTER this rapid glance at other countries, far and near, it may now be well to look back at what has been done in our own, in developing the practice of ship-building, and its accompanying arts in past ages. And first, with respect to

English Vessels before the Fifteenth Century.

The boats used by the earliest inhabitants of this island, so far as there is present evidence, were constructed of wicker-work covered with hides; they were called *coracles* (Fig. 844), and it is curious that very similar vessels, called by the Irish *currach*, and by the Welsh *cwrwgyl*, are in partial use to this day; differing from the older specimens rather in the materials than in the form. Dr. Southey, after speaking of the ancient coracles, says:—"Coracles thus made, differing only in the material with which they are coated, and carrying only a single person, are still used upon the Severn, and in most of the Welsh rivers. They are so small and light that when the fisherman lands he takes his boat out of the water and bears it home upon his back (Fig. 845). In the management of such slight and unsteady vessels great hardihood and dexterity must have been acquired, especially in a climate so uncertain and in such stormy seas as ours."—('Naval History of England.')

There is, however, evidence that the early Britons were acquainted with the mode of constructing canoes out of the trunks of trees; although the means are not at hand for determining the exact period. One has been dug out of a moss near Dumfries; another has been found near Kilblain; several others in the marshes of the Medway; others, again, in the bed of a drained lake in Lancashire; and another near the river Arun in Sussex. Most of these specimens seem to have been hollowed out of a single tree. The last named of them (now deposited in the court-yard of the British Museum, and of which two representations are given in Fig. 840) has afforded the means for examining the structure more distinctly. It was found imbedded in a creek or drain near the village of North Stoke, in a meadow which appears at one time to have been covered by the waters of the Arun. One part of the canoe had been for a long time visible just below the surface of the water, and had been used as a support for one end of a flat wooden bridge which crossed the creek from one part of the meadow to another. For a long time it had been regarded as nothing more than the trunk of a fallen tree; but on the occasion of some improvement being made in the draining of the meadow, eleven horses were employed to drag this submerged mass from its bed; when it was found to be a canoe thirty-five feet long, two feet deep, and four and a half wide. The canoe seems to have been hollowed out of a single oak trunk, and is so excavated as to leave a thickness of three or four inches at the sides and bottom. There are three bars left at the bottom at different distances from each other, and from the ends: these seem to have served the double purpose of strengthening the bottom and giving firm footing to those who worked the canoe; for they are too low to serve as seats. Mr. Phillips, who described this ancient canoe in the 'Archæologia,' after stating his reasons for thinking that it had remained hidden and undisturbed since the time of the ancient Britons, says:—"That in some very early period they should have recourse to the mode in which the canoe, the subject of this paper, was made, to enable them to float upon their rivers for various purposes, though not recorded in their imperfect history, would have been but in conformity of what is known of the like invention by many other people in a similar degree of civilization; and it is adverse to suppose that it should ever be done after the use of iron tools in dividing trees into planks, and the advantage of constructing vessels with wood so divided, because known and practised."

The larger vessels which the Britons were able to bring against Cæsar at the time of the Roman invasion were flatter than the Roman galleys, as being more fitted to navigate tidal-harbours and shoal coasts. They were elevated both at the prow and the poop, and were constructed wholly of oak. The sails were made of skins and thin leather; and it was by disabling their rigging that Cæsar chiefly defeated them: this he effected by attaching sharp bill-hooks to long poles, and catching with these the ropes by which the sails were fastened to the mast; then, the Roman rowers putting forth all their strength, they came up with the enemy and captured the disabled ships.

After the conquest by the Romans, completed by Agricola, they kept a fleet upon the British coast, placed under the charge of a sort of high-admiral, whose duty it was to cruise about the coasts, and clear away the sea-rovers from Norway and Denmark, who had now begun to infest all civilized coasts within their reach. One individual who obtained this office, named Carausius, rebelled against the emperor, caused himself to be made sovereign of Britain, and greatly increased the British navy on the Roman model. He however became involved in incessant contests with the imperial forces, and at length was killed; by which event the British provinces again passed into Roman hands.

It is probable that the vessels which thus formed the Roman British fleet were nearly of the same kind as the Roman galleys of which we have before had to speak, and of which Lord Anson presented a model to Greenwich Hospital. The marble original of this model was found in the Villa Matthei in the sixteenth century, and now stands before the church of Santa Maria at Rome. In Fig. 841 the form of this vessel is represented under several points of view. At the top the side elevation is shown; next below this is the plane or horizontal section; one of the bottom sketches gives the vertical section at "midships," or in the middle of the vessel's length; while the other small figure shows the elevation of the head and the stern, the one to the left and the other to the right. This has been generally looked upon as a model of one of the war-galleys of the Romans; but Charnock, from a consideration of the relative dimensions of the different parts, is of opinion that such a vessel was intended for the transportation of warlike stores, provisions, and troops.

Of the subsequent naval events in England, during the successive irruptions of the Scots, the Picts, and the Saxons, little need be said, for little authentic is known. The next actors on the field of English history, the Danes, being a people who derived most of their subsistence by fishing, had paid great attention to nautical matters, and were by that means enabled to bring over bodies of men to the British coast in vessels which the islanders could not repel. Southey says, the Vikingers, or "sea-kings" of Denmark, at that time were the Arabs of the sea; their hand was against every man, and every man's hand was against them; they boasted that they never caroused over a hearth, nor slept under a smoky roof: but commonly they seem to have roved the seas as long as they continued open; and, when they were ice-locked, to have revelled upon their spoils in some friendly port during the winter. They were bold and hardy sailors; early education on their own stormy seas had given them full confidence in themselves; skill in swimming and dexterity in managing the oar were among the accomplishments of which their chief men boasted: and it is related of one of their kings that he could walk on the oars of his boat while the men were rowing. Such were the men by which Britain was invaded. Some of their vessels were called *æscs;* they were broad-bottomed, but the keels were framed of light timbers, and the sides and upper works were of wicker, covered with strong hides; they were in fact coracles, but of larger size, and provided with a wooden keel. Slight as they were, however, these æses were more formidable than the vessels which Alfred was able to bring against them; and he had others built, having in some instances as many as sixty oars, and evidently partaking of the general character of galleys.

Alfred, by the ultimate defeat of the Danes, established the first standing English fleet, and was himself the first English admiral. His grandson, Athelstan, with a view to raising the mercantile character by making commerce a way to honour as well as to wealth, enacted that any merchant who made three voyages over the high seas, with a ship and cargo of his own, should thenceforward enjoy the rank and privileges of a thane. This naturally led to increased attention being paid to the construction of ships, and appending to them various fittings to adapt them for different seas.

It is impossible to know how far credence may be placed in the accounts given by the early chroniclers of the numbers of vessels which formed the fleets of the Saxons, the Danes, the Normans, and other nations of those days. Many of the statements are so extravagant, and differ so much from others, that they seem to deserve very little belief. Thus, the ships with which William of Normandy invaded England are variously estimated from 696 to 3000 in number. They were, however, of very small size, to judge from such representations as have been handed down to us. In the Bayeux tapestry men are represented drawing the ships to the sea by boats. The ship in which William himself sailed, and which was said to have been presented to him by his queen Matilda, is described as having been distinguishable for the splendour of its decoration by day, and by the light at its topmast by night; its vanes were gilt; its sails were crimson; and at its head was the figure of a child armed with a bow and arrow. When the Conqueror was established in England he felt the desirability of having a permanent naval force; and to effect this he invited foreigners to frequent his ports and build ships there. His successor, Rufus, raised ships by encouraging an underhand sort of privateering.

The several cuts given from Fig. 842 to Fig. 850, derived from tapestries, from manuscripts, from coins, and other sources, will show the kind of war-vessels in use during what may be deemed the feudal times of English history; and there were occasions when a great show was made of such ships. Thus, when Richard Cœur-de-Lion sailed from Sicily to the Holy Land on one of the crusades, his fleet consisted of thirteen vessels called "dromones," characterized by Holinshed as being "mighty great ships with triple sails;" a hundred and fifty "busses," which appear to have been a sort of hulk; fifty-three galleys; and a great number of small craft. There is an allusion to a "busse" or large vessel of Richard's fleet in an ancient poem quoted by Southey:—

> "At noon the tother day, they saw far in the sea
> A grete busse and gay, full high of sail was he.
> The weather was full soft, the wynde held them stille,
> The sail was high o' loft, they had no wynde at will.
> In Philip navie of France, a pencelle they put out,
> His armes on a lance, over all the ship about.
> So mykel was that barge, it might not lightly sail,
> And so heavy of charge; t' the wynde gan fail."

In the contests between the Crusaders and the Saracens, the former learned the use of the "Greek fire," a composition employed as a combustible on board the war-galleys. Most of the galleys had two rows of oars, but those for throwing the fire had but one row. This Greek fire was a composition which was forced, in a liquid state, from hand-engines, or thrown in jars; or else arrows were discharged whose points had been wrapped with tow dipped in it. The management of the galleys and the system of tactics are illustrated by a description of Richard's siege of Acre given by one of the old chroniclers. The Crusaders drew up their fleet in the form of a half-moon; their best galleys being placed at the two ends of the curve, where they might act with the most alacrity and the least impediment. The rowers were all upon the lower deck; and on the upper the soldiers were drawn up in a circle, with their bucklers touching each other. The action began by a discharge of missile weapons on both sides; the Crusaders then rowed forward with all stress of oars, endeavouring either to stave in the sides of the enemy's vessels or to run them down. When they came to close quarters they grappled; and the Greek fire was discharged from vessel to vessel with destructive effects, aided by the personal prowess of the soldiers on board.

English Vessels from the Fifteenth Century.

From the time of the Crusades to the reign of Henry VIII. the naval proceedings of England were chiefly comprised in the conveyance of troops to and fro between England and France, in maintaining actions against the French and Spanish fleets at different times, and in keeping up a coast communication between the different parts of the kingdom. Foreign commerce was much more in the hands of the Genoese, the Venetians, and the Hanse Towns, than in those of England, and our commercial navy was in consequence of limited importance. In the reign of Henry VII., however, a new order of things arose. "The invention and use of gunpowder, at least in Europe, was then of no very ancient date; the introduction into ships was still more recent; and the contrivance of port-holes, the honour of which is attributed to Descharges, a French ship-builder at Brest in the reign of Louis XI., did not take place till nearly fifteen years after Henry had ascended the throne. These separate and progressive additions to, or improvements on, the equipment of a ship intended for warlike purposes, rendered very material alteration in its structure, and an enlargement of its dimensions, indispensably necessary. Previous to the commencement of this new system, no distinguishing line of separation existed between those few vessels which had been specially built for the king's service and such as were used for mercantile purposes, except only that some of the former were of superior dimensions. The case now became altered; and though on occasions of particular emergency it was still found necessary to add, as a reinforcement to the navy, a number of the largest vessels that could be hired, not only from the English merchants, but from the Genoese, the Venetians, and the Hanse Towns, the king's ships began to form a distinct and secluded class, and to be kept solely for the service and use they were constructed to answer."—(Charnock.)

A very remarkable advance indeed must have been made from the feudal times before the "Henri Grace à Dieu" could have been built. Its construction arose out of a contest between the English and French in the Channel. The "Regent," the largest vessel that had up to that time ever been built in England, encountered the "Cordelier," a French ship, having sixteen hundred men on board; and both were clumsy and ill-constructed vessels, very difficult to manage. After engaging for about an hour, the French admiral set his own ship on fire, and the flames communicating to the English ship, both were destroyed. Henry thereupon ordered a new ship to be built, larger even than the "Regent;" and the "Henri Grace à Dieu," or, as it is often called, the "Great Harry," was constructed. This immense ship (Fig. 851) was rated at one thousand tons, and had one hundred and twenty-two guns of various sorts, though only thirty-four of these were such as would now be included in the mention of a ship's power, the rest being very small. There is a

picture at Windsor Castle, and a copy of it at Greenwich Hospital, both of which are supposed to represent this "Great Harry;" the original picture being (as is also supposed) by Holbein. From these representations the ship appears to have been much more bulky and showy than sea-worthy. The king is represented standing on the main deck, with attendants near him; the sails and pendants are of cloth of gold; the royal standard is flying on the four corners of the forecastle, and also on the ship's stern; and the arms of England and France are depicted on the front of the forecastle, and also on the ship's stern. The vessel stood too far out of the water to be safe; and it was but little used. After passing almost a useless existence for about forty years, it was accidentally burned at Woolwich in 1553.

One of the great circumstances which led to the increase of ship-building was the spirit of adventure which sprung up about the reigns of Henry, Edward VI., and Elizabeth. The discovery of America had so excited the cupidity of Europeans of all ranks, that expeditions were sent out one after another, either to colonize new countries already discovered or to discover others. These were sent out in some cases by the government, but in most instances by private persons, either in companies or individually. "The spirit of commerce," says Sir James Mackintosh, "mingled with passion for discovery, which was exalted by the grandeur of vast and unknown objects. A maritime chivalry arose, which equipped crusades for the settlement and conquest of the New World. Great noblemen, who would have recoiled with disgust from the small gains of honest industry, eagerly plunged into associations which held out wealth and empire in the train of splendid victory . . . . For nearly a century it became a prevalent passion among men of all ranks, including the highest, to become members of associations framed for the purpose of discovery, colonization, and aggrandizement, which formed a species of subordinate republics, the vassals of the Crown of England."

It speaks much for the rapidity of the commercial progress, that the fleet which was sent out under Sir Francis Drake in 1587, to attack the Armada in the harbours of Spain, was composed of ships furnished by the merchants of London—not wholly out of a feeling of patriotism, however, for they hoped to pay themselves the outlay by the plunder of the enemy's ships.

The force which the Spaniards were able to bring against England in 1588, under the proud title of the "Invincible Armada," was of such extent as to show that naval tactics had made a tolerably rapid progress. It consisted of one hundred and thirty vessels; of which sixty-five were galleons and large ships, twenty-five were "pink-built" ships, nineteen were tenders, thirteen small frigates, four galeasses, and four galleys. These vessels contained about twenty thousand soldiers, eight thousand mariners, twelve hundred rowers in the galeasses and eight hundred in the galleys, two thousand volunteers, and about twenty-five hundred pieces of artillery. To oppose this enormous force Elizabeth had at first only about thirty vessels of moderate size, but these were increased to a hundred and eighty of various kinds before the contest actually began. What was the disastrous fate of this much-vaunted "Armada" every reader of history knows.

Fuller, speaking of the navy in his time, says:—"Our ships, so active to turn and winde at pleasure, must needs be more useful than the Spanish galleys, whose unwieldiness fixeth them almost in one posture, and maketh them the steadiest markes for their enemies. As for Flemish bottoms, though they are finer built, yet as the slender barbe is not so fit to charge with, they are found not so useful in fight. . . . . . I am credibly informed that that mystery of shipwrights for some descents hath been preserved successively in families, of whom the Petts about Chatham are of singular regard. Good success have they with their skill, and carefully keep so precious a pearl, lest otherwise among so many friends some foes attain unto it." He lays down as a political axiom that "it is no monopoly which concealeth that from common enemies the concealing whereof is for the common good;" and he concludes with the wish, "may this mystery of ship-making in England never be lost till this floating world be arrived at its own haven, the end and dissolution thereof." In the reign of Charles I. considerable advance was made in the art of ship-building. The "Sovereign of the Seas," by far the finest vessel that had up to that time been built in England, was laid down in 1635, and, after existing for fifty years, it was burnt at Chatham. At first it was a lofty and magnificent ship (Fig. 852), the expense of which was one cause of the troubles between Charles and his parliament; but upon being cut down a deck lower, it proved a very formidable ship of war. When we compare this ship and another represented on a medal in Charles II.'s reign (Fig. 853), we find that a tolerably near approach had been made to the form familiar to us in our own day, however different might be the details to a seaman's eye.

It does not form a necessary part of our plan to trace the successive changes in minor matters in ship-building; suffice it to say, that from the time of Blake downwards, the naval history of this country has rendered desirable every possible improvement in the art. There are, however, a few matters which must not be overlooked in respect to the navigation of the Thames.

In bygone times the Thames was the great highway for the metropolis. It was a long land journey in those times from Westminster through the village of Charing to London, and the communication was kept up much more extensively by water than by land. The nobility lived in palatial residences on the shores of the river, as the Venetians do on the shores of their canals, and had stairs, and barges, and watermen devoted to their service. "In the beginning of the seventeenth century the river was at the height of its glory as the great thoroughfare of London. Howel maintains that the river of Thames hath not her fellow, 'if regard be had to those forests of masts which are perpetually upon her; the variety of smaller wooden bottoms playing up and down; the stately palaces that are built upon both sides of her banks so thick, which made divers foreign ambassadors affirm that the most glorious sight in the world, take water and land together, was to come upon a high tide at Gravesend, and shoot the bridge to Westminster.' Of the 'smaller wooden bottoms,' Stow computes that there were in his time as many as two thousand; and he makes the very extraordinary statement, that there were forty thousand watermen upon the rolls of the company, and that they could furnish twenty thousand men for the fleet. The private watermen of the court and of the nobility were doubtless included in this large number. It is evident, from the representations of a royal procession in the early times of James I., that, even on common occasions, the sovereign moved upon the Thames with regal pomp, surrounded with many boats of guards and musicians. The inns of court, too, filled as they were not only with the great practitioners of the law, but with thousands of wealthy students, gave ample employment to the watermen."—*London*, No. 1. How different are matters now, with the scores of steamers rattling up and down the river! (Fig. 854.) Royal and noble personages have given up the Thames to the middle classes; and the only "barges" now on the Thames (except a few for special occasions) are those intended for the purposes of commerce, such as the coal-barges, the corn-barges (Fig. 860), and the up-river barges tracked by horses (Fig. 856). The fishing-boats of the Thames (Fig. 857) belong to another class, and partake of much the same characters as fishing-vessels generally.

Varieties and Internal Arrangements of English Vessels.

The several parts of which a large vessel consists are so varied as almost to baffle enumeration; and it is impossible to regard them without a feeling of admiration at the skill developed in their construction. In proceeding upwards from a boat to a man-of-war, we find that the complication increases by successive steps. First, there is the *boat*, with all its sub-varieties of *wherry, long-boat, pinnace*, &c., all of which are without decks, whatever points of difference they may present in other respects. Then comes the class of *sloops* and *cutters*, which are the humblest forms of regular sailing vessels; these generally carry four sails, known technically as the "main-sail," "top-sail," "jib-sail," and "fore-sail," all in a line with the keel; they have only one mast and a bowsprit. The next class includes the two-mast vessels, such as *brigs* and *schooners;* the former being "square-rigged," that is, having the sails spread out at right angles to the length of the keel; and the latter having the sails more nearly resembling those of a sloop. It is only when a vessel is "square-rigged" that it generally obtains the name of a *ship*, and this general appellation is seldom applied but to three-mast vessels. The three-mast vessels engaged in commerce have the general name of *merchantmen;* while those forming the royal navy obtain the names of *men-of-war, ships of the line*, and *frigates*, according to certain differences as to rank or size; the distinction being still further carried out by the denomination of 1st rate, 2nd rate, and so on to the 6th rate.

In a first-rate ship of war there are four complete decks reaching from one end to the other, besides partial decks above them. The lowest deck, called the *orlop*, contains the rooms occupied by the surgeon, the purser, the boatswain, and the carpenter, and other rooms and berths for sails, and also the mess-rooms of the midshipmen. Below the orlop-deck is the vast space denominated generally the *hold*, which in merchantmen contains the cargo, and in war-ships contains the gunpowder, the bread, the spirits, the salt provisions, and various other stores, all kept in separate compartments, and governed by the most scrupulous regulations. On the *lower* deck, above the orlop, are mess-rooms and sleeping berths for the sailors; it also contains the great capstan, by the action of which the heaviest anchors are weighed. The galley or kitchen of the ship is also situated here; this kitchen contains an immense boiler, and all the conveniences for dressing the meals of (perhaps) a thousand men. Above that deck is the *middle*-deck, and above this is the *main*-deck, containing the admiral's cabin and various other rooms. This main or upper deck differs from the others in being partially uncovered: it is roofed at the foremost end by the *forecastle*, a short or partial deck, and at the hinder end by the *quarter-deck*, another partial deck. The after part of the middle-deck contains the *ward-room*, or cabin for the lieutenants; immediately above this, on the main-deck, is the admiral's state cabin, where the captain or chief officer occasionally invites the other officers to join him at dinner; and immediately over this again is the captain's berth or sleeping cabin, on a level with the quarter-deck, and covered by another partial deck called the poop. All the ship's crew have their respective places according to rank; thus the able or best seamen consider the forecastle as their territory, while the inferior seamen occupy the "*waist*" or middle part of the ship.

A first-rate man-of-war, carrying 120 guns, is generally rather over two hundred feet in length at the lower-deck, and a hundred and seventy at the keel; the width of the widest part is above fifty feet, and the height from the keel to the figure-head is about the same, or rather more. All the decks of a man-of-war, except the orlop-deck, carry guns; and the whole arrangement of the ship is made subservient to the proper working of these guns. Even the admiral's state cabin, with its sofas, carpets, and other luxuries, has two or more enormous guns pointed towards the windows, with all the necessary appendages for bringing them into action when the hour of battle arrives. The berths or sleeping-places of the officers, too, wherever they are situated, though enclosed from each other under ordinary circumstances, are all thrown open to the deck when an action is to commence, by knocking away the partitions or "bulk-heads" which separate them.

The masts, yards, sails, and ropes on board a ship are so numerous that it would require no small amount of schooling on the part of a landsman to learn even their names. The "main-mast," the "mizen-mast," and the "fore-mast," the "top-mast," and the "top-gallant-mast," the "yard," the "jib-boom," the "bowsprit," the "gaff,"—all are spars of wood of immense length, contributing in various ways to the support of the rigging. Then among the sails there are the "main-sail," the "fore-sail," the "top-sail," the "top-gallant-sail," the "royal," the "sky-scraper," the "studding-sails," the "stay-sails." A similar variety of odd names occurs in respect to the ropes or lines.

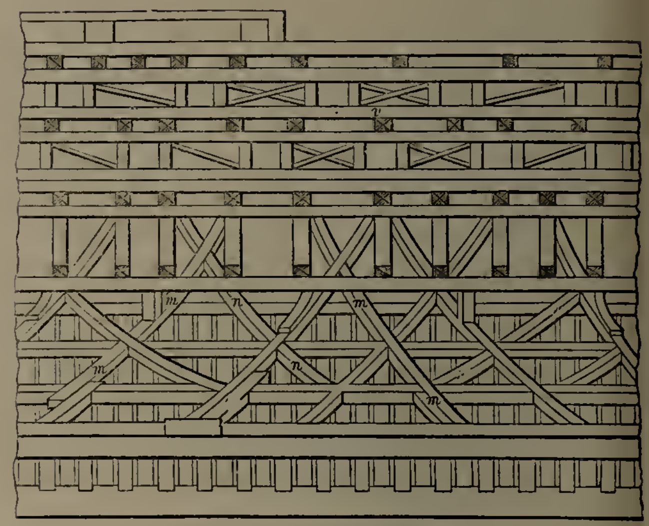
One of the most interesting modes of obtaining a knowledge of the internal economy of a ship, both moral and material, is to watch the course of the examination which a ship of war undergoes on a Sunday morning. Captain Basil Hall, in his second series of 'Fragments of Voyages and Travels,' has treated this matter in his usual graphic and lively style; and to his description we will have recourse.

Sunday on board a ship of war is always marked more or less by some religious service, but especially by the scrupulous cleanness of everybody and every object on board. "The decks, for instance, receive such a thorough allowance of holy-stoning and scrubbing on Saturday, that a mere washing, with perhaps a slight touch of the brushes and sand, brings them into the milk-white condition which is the delight of every genuine first-lieutenant's heart. All this is got over early in the morning, in order that the decks may be swabbed up and the ropes nicely flemished down before seven bells, at which time it is generally thought expedient to go to breakfast, though half an hour sooner than usual, in order to make the forenoon as long as possible. I should have mentioned that the hammocks are always piped up at seven o'clock. If they have been slung overnight, they are as white as any laundress could have made them; and, of course, the hammock-stowers take more than ordinary care to place them neatly in the nettings, with their bright numbers turned inwards, all nicely lashed up with the regulated proportion of turns, each hammock being of a uniform size from end to end." An allusion is here made to "seven bells," a term requiring a little explanation. The mode of keeping time on board a ship is curious. The day is divided into periods of four hours each, called "watches," and each watch is marked off into eight periods of half an hour each. At each of these half-hours a bell is rung, as many strokes being given as half-hours have elapsed in that watch. For instance, the "morning watch" lasts from four till eight o'clock in the morning, and "seven bells" in that watch indicates half-past seven.

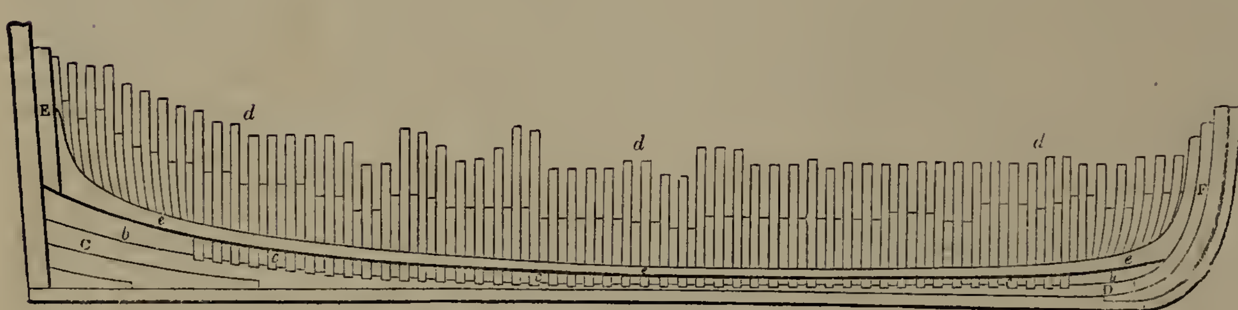
The order to the men to dress for muster is given out by the captain, the kind of dress ordered being dependent on the state of the weather and other circumstances. The boatswain sings out the order after the captain, and his mates after him, in tones which are heard throughout the ship. The order may be, "Clean for muster—duck frocks and white trowsers!" or "Blue jackets and trowsers!" or "Clean shirt and a shave!" The men shave on Tuesdays and Thursdays, and wash their clothes on Mondays and Fridays. From eight o'clock to half-past ten on the Sunday

861.—Dockyard and Man-of-War, at Sheerness.

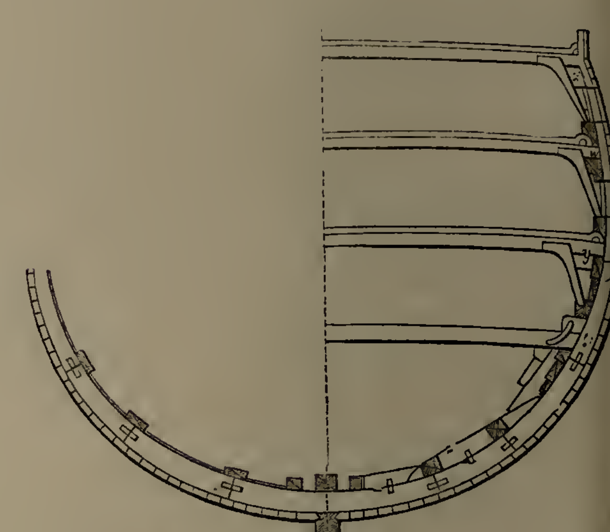
860.—Thames Corn-barge.



864.—Timber Framing of a Ship.



863.—Section of a Ship's Timbers, from stem to stern.

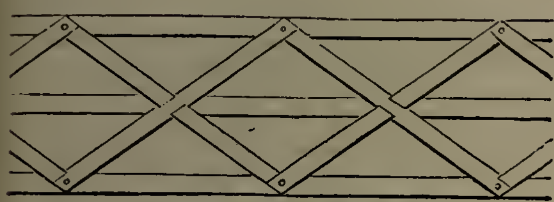


865.—Transverse Section of a Ship's Timbers.

862.—Ship-building Yard.

866.—Trough for steaming Planks for Ships.

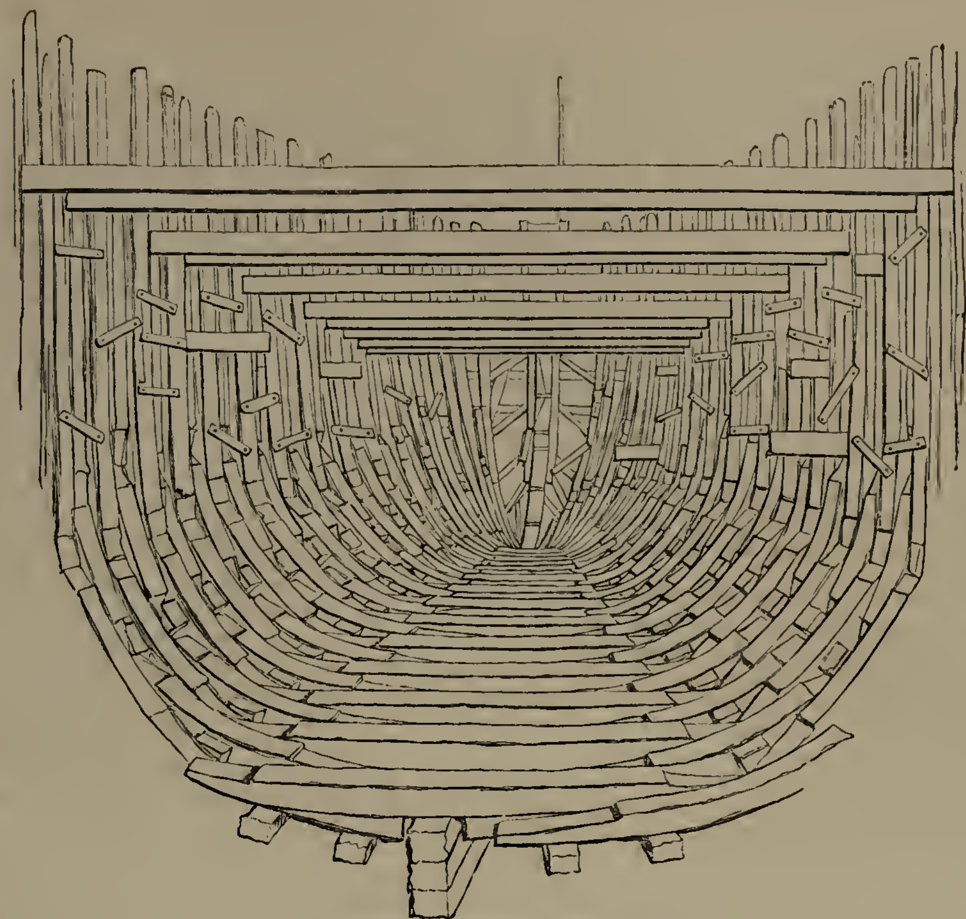
869.—Making "Trenails," or Oak Pegs.



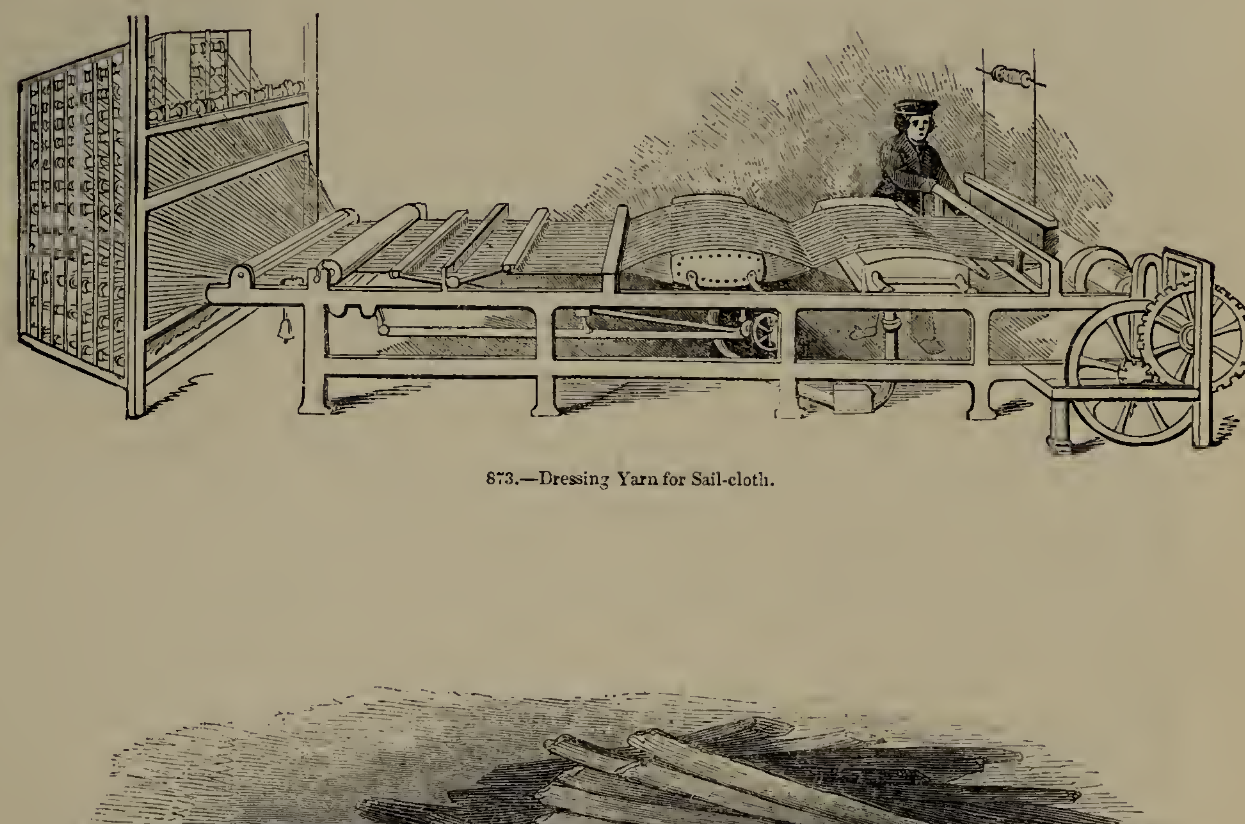
867.—Diagonal Bracing of a Ship.

868.—Boring "Trenail" holes in Ship's Planks.

870.—Spinning Oakum-threads for Caulking.



871.—Frame-Timbers of a Ship, while building.



873.—Dressing Yarn for Sail-cloth.

872.—"Hooping" a Mast, or driving on the Iron Rings.

morning, the lower decks are scrubbed and swept most thoroughly, and the whole ship is in a bustle of preparation for the examination which is to take place at the last-mentioned hour. At this hour the mate of the watch, directed by the officer on deck, who again acts in obedience to the captain's orders, conveyed through the medium of the first lieutenant, calls out—"Beat to division!" Before this period arrives, the mate of the decks and the mate of the hold, the boatswain, gunner, and carpenter, have all severally received reports from their subordinates that their different departments are in proper order for inspection. Reports to the same effect being then finally made to the first lieutenant by the mates and warrant-officers, he himself goes round the ship to see that all is right, preparatory to the grand inspection. The bedding has been previously brought up, so that nothing remains between decks but the mess-tables, stools, and vessels.

When the drum beats, at half-past ten, the ship's company range themselves in a single line along both sides of the quarter-deck, the gangways, and all round the forecastle. In a frigate the whole crew may be thus spread out on the upper-deck alone; but in line-of-battle ships the numbers are so great that similar ranges, each consisting of a division, are likewise formed on the opposite sides of the main-deck. The marines, under arms and in full uniform, fall in at the after-part of the quarter-deck; while the ship's boys muster on the forecastle. Each division of the ship's company is under charge of a lieutenant, who, as well as the midshipman of his division, appears in full uniform. The lieutenant examines the dress and appearance of every man in his division separately; and it is usual, in hot climates, for the surgeon to pass along the ranks, and see whether there are any symptoms of scurvy or other disease in the appearance of the men. The midshipmen call over the names, to which the men answer; and the officers proceed in their examination.

When all is ready the captain and the first lieutenant leave the quarter-deck, and proceed on the examination—the first lieutenant being, to a certain extent, responsible to the captain for the proper condition of everything in the ship. "A pin might now be heard if let fall anywhere on board; and, but for the sound of the wind amongst the cordage, or the stroke of a slack rope against the mast, or the occasional shake in the weather-leach of a lofty sail, braced rather too fine; and, except for the rippling sound of the water about the bows, and the creaking caused by her heeling over under the pressure of the wind, the ship might be supposed to be unmanned, and lying dismantled in the basin of Portsmouth harbour. As the captain approaches the first division he is received by the officer commanding it, who touches his hat, and then falls into the train behind. Of course, the moment the skipper (captain) appears, the men along the whole line take off their hats, smooth down their locks, make many clumsy efforts to stand erect, fumble interminably with the waistband of their trowsers, and shuffle, to more or less purpose, according to the motion of the ship, to maintain their toes exactly at the line or seam in the deck along which they have been cautioned twenty times they are to stand. The captain, as he moves slowly past, eyes each man from head to foot, and lets nothing pass of which he disapproves. The officer of the division is ready to explain, or to take a note of what alteration is required; but, supposing all to be right, not a syllable is spoken, and at the end of the division the captain again touches his hat to the officer, who returns the salute, and remains with his people. He then proceeds to the forecastle, at the break of which he is received by the three warrant-officers—the boatswain, gunner, and carpenter—in their best coats, cut after the fashion of the year one, broad-tailed, musty, and full of creases from bad packing and little use, and blazing from top to bottom with a double-tiered battery of buttons of huge dimensions. Behind these worthy personages, who seldom look much at home in their finery, stands the master-at-arms, in front of his troop of young scamps—not the young gentlemen, but the troublesome small fry known by the name of the ship's boys, destined, in good time, to be sailors, and perhaps amongst the best and truest that we ever number in our crews."

Before leaving the upper-deck the captain proceeds to inspect the marines, who are drawn up on the quarter-deck. The two divisions ranged along the main-deck next engage his attention; after which he is received by the cook and the cook's mate at the galley or kitchen. Here the lids of the coppers are taken off, to show that all is clean and right within; a little of the "peas-soup" is drawn off, to show that its quality is proper; the oven-doors are opened, and all the arrangements are exposed to view, to test their cleanliness and order. The captain then visits the sick-room or hospital, where he is received by the surgeon and his assistants, and where even a greater degree of scrupulous cleanliness is expected than in any other part of the ship: the invalids are visited one by one, and a kind word or two given to each.

Next comes the examination of the lower-deck, which is at this time chiefly occupied by the mess-tables and vessels for meals, many of which are polished to a resplendent degree of brightness. "The intervals between the shelves are generally ornamented with a set of pictures of rural innocence, where shepherds are seen wooing shepherdesses, balanced by representations of not quite such innocent Didos weeping at the Sallyport, and waving their lily hands to departing sailor-boys. On the topmost shelf stands, or is tied to the side, a triangular piece of a mirror, three inches perhaps by three, extremely useful in adjusting the curls of our nautical coxcombs, of which one at least is to be found in every berth. The mess-tables, which are kept so bright you would suppose them white-washed, are hooked to the ship's side at one end, while the other is suspended by small ropes covered with white canvas. Against these lines rest the soup and grog kids (vessels), shining in a double row along the deck, which is lighted up, fore and aft, for the captain's visit, by a candle in each berth."

As the captain proceeds, he visits, one by one, the mess-rooms of the midshipmen, the berths of the marines, and those of the boatswain, gunner, and carpenter. The warrant-officers' berths are also examined; but those of the superior or commissioned officers, though glanced at as a matter of form, are not examined, since these officers, moving in the rank of gentlemen, are supposed to have gentlemanly habits in all that respects neatness and order.

A next lower stage, containing the purser's store-room, the bread-room, the spirit-room, the store-rooms under the care of the boatswain, the gunner, and the carpenter, are more scrupulously examined, since the well-ordering of a ship essentially depends upon everything being in its proper place at the proper time. At length, when every part of the fittings on all the decks has been thus examined, and half-an-hour has been thus spent, the captain returns to the quarter-deck, and gives instructions to "rig the church." The benches, the mess-stools, and the capstan-bars are arranged along the deck, as seats for the men, while chairs are brought out of the cabins as seats for the officers. The chaplain takes his place about the middle of the group, and is provided with a temporary pulpit and hassock. An awning is spread overhead, and curtains are hung to keep out the heat of the sun; but in stormy weather the church is held beneath the half-deck. A signal is hoisted, to indicate to any other ship that prayers are about to commence; and this signal is scrupulously attended to, to the avoidance of any interruption. If there is no chaplain, the captain officiates as such, and either reads prayers only, or also reads a sermon, according to his own sense of propriety in the matter.

Although it relates to the personal concerns of the seamen, rather than to the mechanical arrangements of the ship, a few words may be said in relation to the "slops," or clothing of the crew. It is frequently the custom in the Royal Navy to "muster clothes at divisions" on Sunday, and to take a list of what slops are required by the men. "Slops" is the odd-sounding name applied to the new clothes provided for seamen; and the "kit" is the collective name for the sailor's wardrobe. The inspection takes place once a month. A drum beats at a particular hour as a signal; and each man, bringing his bag to the place where he stands in his division, proceeds to arrange his things in order before him on the deck, each article being placed separately, that the officer may count and examine them. The mates and midshipmen first call over the names, to ascertain that every man has the proper complement of articles, in good order and well washed. A note is taken of what things are wanted, in the way of slops, to supply worn-out and condemned clothes; and the result is given in detail to the lieutenant of the division, who continues walking backward and forward, ready to answer any appeals in the case of difficulty arising. He carries in his hand a complete list of his division, and of each man's clothes; and when he has heard the reports of the subordinates, and made a cursory examination himself, he makes out a list of the slops wanted, and hands it to the captain, who, if he approves of it, gives an order to the purser to supply them out of the stores placed in the hands of the latter by the government agents.

Captain Hall remarks:—"I suspect few people have the smallest notion of what a sailor's wardrobe consists. Every one has, indeed, a vague idea that he must have a blue jacket and trowsers, and a low canvas shining sort of an affair stuck on one side of his head, and called by him a hat. But of any further particulars the shore-going world really know about as little as they do respecting the dresses of the Emperor of China. Honest Jack, it is very true, is not much encumbered with clothes; and too often his wardrobe sadly resembles that of the Honourable Mr. Dowlas, which was easily transportable in the Honourable Mr. Dowlas's pocket handkerchief. Yet if he have the opportunity, poor fellow, and be duly encouraged, he is not a little of a dandy in his way."

In a well-regulated ship, for our own climate, a sailor's "kit" consists of two blue jackets, a large shaggy surcoat called a pea-jacket, two pair of blue trowsers, two pair of shoes, six shirts, four pair of stockings, two Guernsey frocks made of a kind of hosiery, two hats, two black handkerchiefs, a worsted comforter or neck-wrapper, and several pairs of flannel drawers and waistcoats. For warm climates the dress is different—duck-frocks, white trowsers, and straw-hats taking the place of warmer clothing. Each seaman has, besides, a bed, a pillow, two blankets, and two hammocks, or suspended bed supports, one of which is slung and in use, while the other is kept clean till wanted.

THE CONSTRUCTION OF SHIPS, AND THEIR APPENDAGES.

The building of ships is carried on at two different classes of establishments: the one, government dockyards, provided with all the facilities for conducting the operations on a magnificent scale; and the other, private ship-yards, much more numerous, but of far inferior magnitude. Of the former, Woolwich, Deptford, Chatham, Sheerness, Portsmouth, Plymouth, and Pembroke are the principal. Of the latter the chief seats are London, Bristol, Liverpool, Hull, Glasgow, Sunderland, and Shields. To give an idea of the magnitude on which the government ship-building arrangements are conducted, it may be well to glance at the

Royal Dockyards.

The dockyard at Portsmouth is the most capacious and complete of them all. It comprises an area of a hundred acres, and has a sea-wall three thousand five hundred feet in length. In the centre of this wall is the entrance to the great basin, into which open four dry docks; and these four, with two others adjacent, are all capable of receiving ships of the largest class. There is also a double-dock for frigates, and several smaller docks. In the same part of the yard are three building-slips, capable of receiving the largest ships; and other smaller ones for sloops and frigates. Among the buildings belonging to the yard is a magnificent range of storehouses, six hundred feet in length; a rigging-house and a sail-loft, not much less in extent; two hemp-houses and two sea-store houses, reaching nearly eight hundred feet in length; a rope-house and a tarring-house, of nearly equal length; timber-berths, saw-pits, and sawing-machinery; a smithey, an iron-mill, a copper-mill, a copper-refinery, and a casting-house; the admirable "block-machinery," constructed by Mr. Brunel, and machinery for turning various articles in wood. All these arrangements are on so fine a scale that, when the establishment is in full work, it gives employment to about four thousand artisans. Besides the dockyard, properly so called, the arsenal comprises a victualling establishment, containing a bakery for making biscuits, a brewery, a cooperage, and numerous provision-stores and magazines.

Plymouth dockyard is slightly smaller than that of Portsmouth, but its general arrangements are nearly as complete. It extends in a circular sweep on the shore of the Hamoaze for a distance of three thousand six hundred feet. It contains two drydocks for first-rate ships, a double-dock for "seventy-fours," another of a similar kind at a different spot, together with repairing-docks and building-docks. Plymouth dockyard contains the finest ropery in the kingdom, consisting of two buildings, each three stories in height, and twelve hundred feet long.

All the other royal dockyards exhibit such features as the above, more or less fully developed; and most of them, in general, have ships "in ordinary," or laid up near them, as in the instance of Sheerness. (Fig. 861.) Each establishment has some particular points for which it is distinguished. Deptford, though inferior to the others in ship-building arrangements, is the great centre for naval stores, such as cordage, canvas, hammocks, and seamen's clothing; and its victualling establishment is one of the finest in the kingdom, comprising a corn-mill, a cooperage, a brewery, a butchery, and a bakery—all distinct buildings: it is said that the corn-mill could grind flour enough to make biscuits for the whole British navy. Chatham has to boast of the finest saw-mill in the kingdom, containing Mr. Brunel's machinery for sawing timber.

Sir John Barrow, in his account of dockyards in the 'Encyclopædia Britannica,' gives a *beau ideal* of what he thinks a dockyard ought to be to render the full amount of service; and the reader will derive from this a tolerably good notion of the several parts of such an establishment. He supposes a large basin to form the nucleus or heart of the arrangement. "The docks and slips should occupy one of the sides of the basin, with working-sheds for carpenters and joiners, smiths' shops, saw-pits, and seasoning-sheds between them. The ship, when completed in the slip, and launched into the basin, may then be taken immediately into the adjoining dock to be coppered. From this she proceeds to the second side of the basin, in the corner of which is the ballast wharf: the remainder of the side will probably be occupied by the victualling department, with appropriate stores in the rear for various kinds of provisions, and behind these the bakery, brewery, and slaughter-houses; on the wharf the iron tanks for holding water,

now universally used for the ground tier, in lieu of wooden casks. These are taken on board next after the ballast, and, together with the superincumbent casks, would be filled in the ship's hold by means of flexible pipes to convey the water into them. The provisions would at the same time be taken on board at the same wharf, in front of the victualling stores. The third side might be appropriated to the ordnance department, with the gun-wharf extending along the whole side, and the gun-carriage storehouses, magazines, &c., in the rear. The fourth side would be occupied as the anchor wharf, with the cable storehouses, the sail-lofts and stores, rigging-loft, and magazines for various stores in the rear. Behind these, again, on the first side, containing the dry docks and building-slips, the ground would be appropriated to the reception, berthing, and converting of timber, from whence iron railways would lead to the saw-mills, saw-pits, and workshops, all of which would be placed on that side. On the second side a pond or basin for the victualling lighters and craft, with wharfs communicating with the manufactories and storehouses; the same on the ordnance or third side; and on the fourth side might be placed the ropery, hemp-storehouses, tar-houses, with a basin for hemp-vessels, lighters, and the like, communicating with the great basin on the building side, and also with the river or harbour; on the shore of which the dock-yard is to be formed, should be a mast-pond, with a lock for the storing of spars; in front the mast-houses, top-houses, capstan-houses, and a slip to launch the masts into the pond. Here also might be placed the boat-houses and boat-pond."

The Planning and Architecture of Vessels.

The whole of the arrangements just noticed, and others of a more or less similar character observable in private ship-yards, are subservient to the one main object of making a mighty floating machine, which shall bear the rough usage of stormy seas. To attain the requisite combination of strength and buoyancy is the great object of the shipwright's art. We may illustrate one peculiar variety of it by referring to the structure and qualities of "life-boats."

The construction of a boat in such a manner as to fit it to brave the fury of the waves, and thereby to act as a life-boat, has been the object of many contrivances at different times. The object to be attained may be thus stated—to form a boat so light that, even when full of water, it will not sink. About forty years ago Mr. Greathead of South Shields received a gold medal from the Society of Arts for the construction of a boat having this object in view; and he furthermore received grants from the Government, from the Trinity House, and from Lloyd's, as a reward for his ingenuity. The length of this boat (Fig. 858) is thirty feet, its breadth ten, and its greatest depth about three, besides a general curvature which nearly doubles the depth, as reckoned from the ends; the convexity below being intended to give it a greater facility of turning, and a greater power of mounting on the waves without submersion of the bow, which would increase the resistance, though it would not sink the boat; the breadth is also continued farther than usual fore and aft, in order to contribute to the same property. The gunwale projects some inches, and the sides below it are cased with pieces of cork, amounting in the whole to seven hundredweight, which are secured by plates of copper. There are ten short oars of fir, fixed on pins to the gunwales, and a longer oar for steering at each end, both ends of the boat being alike. It is painted white, in order to be more conspicuous; and a carriage is provided (Fig. 859) for conveying it overland when required.

The rewards were not given to Mr. Greathead until an investigation before a committee had shown that many hundred lives had been saved by means of his invention. One of the witnesses examined stated that he had seen the life-boat go off scores of times, and never saw her fail in bringing away the crew from wrecks, or vessels in distress. No other boat could have gone from the shore at the time the life-boat went. He also stated that, in the event of the life-boat filling with water, she would still continue upright, and not founder, as common boats would do. Another individual had been witness to the wreck of several ships at the same time. Out of one vessel the life-boat took fifteen men, who would otherwise inevitably have perished.

Numerous modifications of life-boats have since appeared; indeed, there is scarcely a year passes without some new invention relating to life-boats, fire-escapes, and other similar contrivances—all of which seem to show that, however praiseworthy the contrivances may be, there are some points or other in respect to which all are deficient. Sometimes boats have been constructed with projecting gunwales and hollow cases, or double sides under them, as well as air-tight lockers or inclosures. Copper air-vessels have frequently been used as part of the boat's fittings, the buoyancy thereby attained being one of the objects in view.

In making the general class of vessels, however, greater strength, with less buoyancy, are required; and it is curious to see how the naval architect puts in practice his plans for producing such vessels. One of the first buildings in a ship-yard where the operations are carried on is the "mould-loft." This is a room, the length of which rather more than equals half the length of the largest ship to be planned there; and on the boarded floor of this loft innumerable lines are chalked, to mark the several parts of the vessel. The architect, in the first place, draws out his plan upon paper, on a scale of a quarter of an inch to the foot; and from this plan he marks the lines on the mould-loft floor the full size of the intended ship. This chalked plan comprises a horizontal plan of half the ship in the direction of its length, and a transverse section of the ship at its greatest breadth. From these as a standard the architect proceeds to chalk numerous other lines, representing the timber ribs or frames which form the hull of the vessel. Thin pieces of plank are taken, about three-quarters of an inch in thickness, and cut into forms corresponding with the lines on the floor. These shaped pieces, which constitute collectively the "mould" of the ship, are intended solely to guide the shipwrights in cutting their various timbers to form the hull of the vessel. The concave and convex edges of the mould-pieces, and certain chalk-marks upon their surfaces, give the length, breadth, depth, and peculiar form of all the ship's timbers. So numerous are the various timbers required for a large ship, that in planning an East Indiaman more than a hundred of these moulding-pieces are prepared.

If we look at Figs. 863, 864, 865, 867, 871, we shall see how varied are the forms of these timbers, intersecting each other at almost every imaginable angle. The main timbers which form the ribs, or framework of the hull, are, in particular, remarkable for their curvatures—since it is by these curvatures that the general shape of the vessel is determined. The proprietor of the vessel determines, in the first instance, what shall be the "tonnage" of the vessel, or the general capacity of the hull, and the relation between the length, breadth, and depth; and the ship-architect then determines how to attain this object in practice. It is his office, also, to attend to all improvements which may be made in the effect of the vessel's form upon the speed attained, and to devise the means for working them out practically. The result of all his labours, however complex they may be, is shown in the set of "mould-boards" which he prepares, and which forms the connecting link between the naval architect and the shipwright.

Forming the Hull or Framework of a Ship.

When the "mould" is prepared, the pieces of which it consists are handed over to the master-shipwright to assist in building the vessel; and then commence the busy operations of the ship-yard generally (Fig. 862). The "converter" is one of the first persons employed in this important train of operations: his duty consists in selecting the logs of timber fitted for each particular purpose, and superintending the shaping of them. The oak and elm trunks which form the principal materials for the framework of a ship are very varied in size and shape, and considerable judgment is necessary in selecting them; for the direction of the grain is an important element in the strength of a piece of timber. Suppose, for illustration, that a beam with a peculiar curvature was required: if a "knotted and gnarled oak" could be found, whose crookedness of trunk bore some resemblance to the curvature of the intended timber, it would not only be a saving of material to use this trunk for such a purpose in preference to another, but the beam so produced would be actually stronger, since the direction of the grain would conform pretty nearly with the curved form of the timber. Such is the kind of skill in selection which the "converter" has to show; and he must also possess an intimate knowledge of the quality of timber, not only from its appearance when cut, but from its exterior, as a means of determining the fitness of every particular piece for the purpose to which it is to be applied.

When the proper logs are selected they are placed across a saw-pit in the usual way, and cut by saws worked vertically by two men. The "mould-boards" are applied to the logs one by one, and the cuttings of the saw are made in conformity with them. Instead of cutting rectangularly, as in common saw-pits, the logs are placed at various angles, so as to be cut into the seemingly-strange shapes which so many of the timbers of a ship present; and the directions of the cuts vary so remarkably and so frequently, that it is found impracticable to apply machinery to the cutting of the timbers. In the saw-mills of the Royal dockyards, lately alluded to, those portions of planking of other woodwork of a ship, which are tolerably regular in shape, are cut by machinery; but the shaping of the main timbers is essentially hand-work.

The sawing, or "converting," is carried on under sheds; and the pieces, as they are cut, are carried to the "building-slip," or place where the ship is to be constructed. This is generally an oblong space declining gently towards the sea, or a river, or a basin, in such a manner that the ship, when finished, may slide down into the water at high-tide. The ground is cleared and made smooth, and a row of blocks is laid down, each block being transverse to the length of the ship, and the whole being sufficient in number to extend from end to end of the slip; they are made of oak, and are piled one on another to the height of three or four feet. The upper surfaces of all the blocks are in a straight line, slightly declining towards the water.

These blocks form the support on which the whole of the ship is built, beginning with the keel. This important part of a vessel's frame or body, forming, in fact, the back-bone of the whole structure, is made of elm; and, as no elm-tree is long enough to make it, except for small vessels, two or three trunks are joined or "scarfed" together to produce the required length. It may well be supposed that great strength must be exhibited in the mode of scarfing, to enable the keel to bear the enormous strain to which it will afterwards be subjected. The keel is grooved and cut in various ways, for the reception of other timbers, both at the sides and the ends.

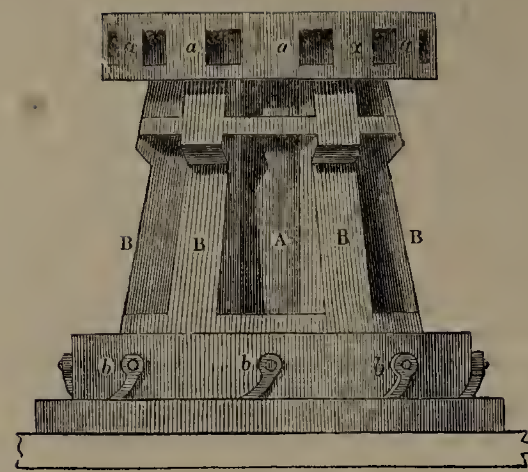
As the keel is the main support of the bottom, so are the "stem" and the "sternpost" the main supports of the two ends. The stem is a large timber which rises in a curved form from one end of the keel, and the sternpost is another that rises nearly perpendicularly from the other end; both are formed of oak, and both are attached to the keel with great strength. Adjacent to and contributing to the object of these timbers are several others, called by the various names of "transoms," "fashion-pieces," &c., most of which assist in forming the connexion between the head and stern and the side-timbers. Many of these timbers are formed of two or more pieces joined together; and, being of immense weight, they are hauled up by pulleys, and supported by shores or poles until they can be adjusted to their places.

The first approach towards forming the body of the ship is made by laying down the "floor-timbers." These are pieces of wood laid side by side across the keel, and fastened down to it, except towards the end, where they are lifted from the keel by the interposition of timbers called "deadwood," in order to make the floor of the ship curve upwards from the middle towards the ends. Then, springing from these and from the keel are the side timbers which form the ribs of the ship. These extend up to the very top of the hull; and as the height is too great and the curvature too deep for any one timber to form a complete rib from the keel to the top, many timbers are joined together end to end for this purpose. Each timber so employed is called a "futtock" or "foot-hook;" and the various futtocks for one rib, called the "first," "second," "third," and so on, together constitute a "frame of timbers." If the ship is small, all the pieces to form one "frame" are bolted together on the ground, and raised collectively into their place by means of pulleys; but in a large ship this "frame of timbers" would be too ponderous, and it is therefore raised in two or three masses. All the various pieces are bolted together, end to end and side by side, so as to support each other; and thus operations go on, each "frame of timbers" being raised and adjusted in its turn, until the whole length of the vessel is rudely formed. They are supported externally by planks called "ribbands," and internally by beams stretching across from side to side.

In the state to which the building has now arrived, it presents internally the appearance presented in Fig. 871, where the eye is supposed to be placed about the middle of the vessel within-side, and to be looking towards one end; the keel, the floor-timbers, and the various rib-timbers being visible in their respective places. In Fig. 863 we have it under a different aspect. Here the ship is supposed to be cut down the middle from end to end, so as to show the relative positions of the timbers. At the bottom is the keel, from whence the "sternpost" rises at one end, and the "stem" at the other; at the level *b* are the "floor-timbers," and C D is the "deadwood" interposing between them and the keel; *d d* are the ribs of the vessel; *e* and E and F are three pieces designed to strengthen the keel, the stern, and the stem, and called respectively the "keelson," the "sternson," and the "stemson."

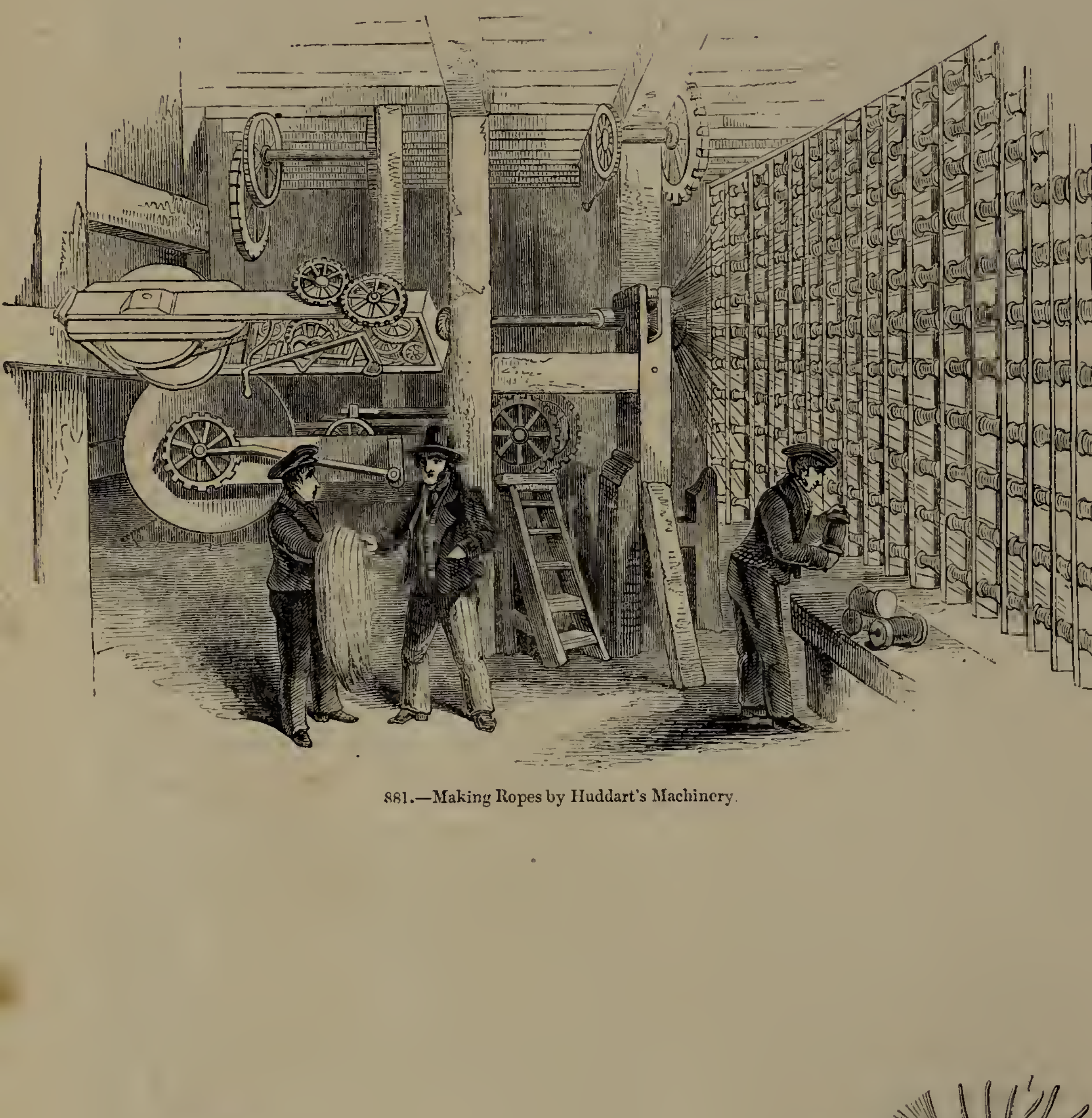
The "beams" of a ship are the bulky timbers which stretch across from side to side, serving both to retain the hull in its proper shape and to support the decks. If the vessel be a small one, a single timber will form a beam; but if it be large, three timbers are scarfed together, end to end. There are thirty or forty of such beams under the main-deck of a large ship, each one being so curved as to present a rise in the centre, amounting to about one inch to a yard. They are supported in the middle by pillars or vertical beams, and at the ends by various fastenings called "clamps" and "knees," some of which are of very ponderous character. Besides these beams, the framework of a ship requires for its support numerous diagonal "braces," or pieces, either of iron or of wood, fixed in various directions on the inside of the main timbers, so as to avoid as much as possible their yielding. This is a very important feature in naval architecture, to which the attention of Sir Robert Seppings and other scientific

874.—Caulking Ship's Planks with Oakum.



875.—Capstan for Ship's Cable.

882.—Sail-making.



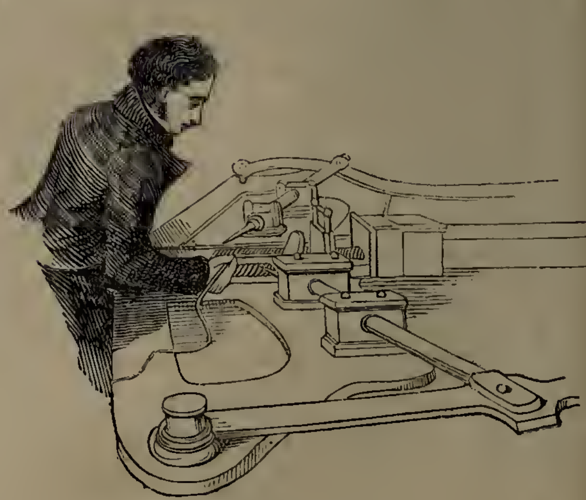
881.—Making Ropes by Huddart's Machinery.

877.—Rope-Yarn Making.

880.—"Serving" or Binding a Rope.

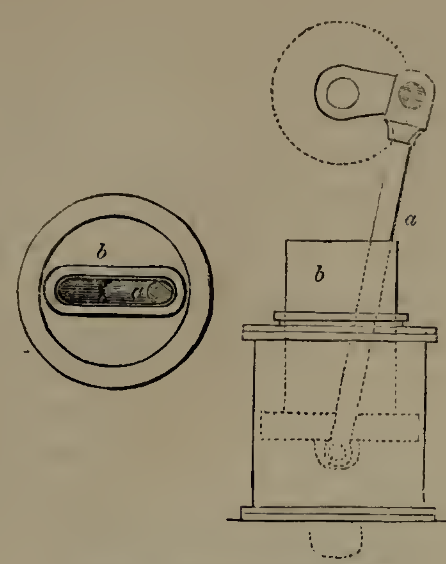
878.—"Laying" or Making a Rope.

876.—Analysis of a Rope.

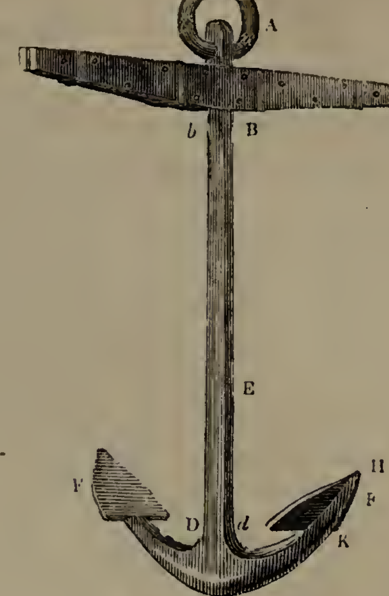


879.—Flat-Rope Making.

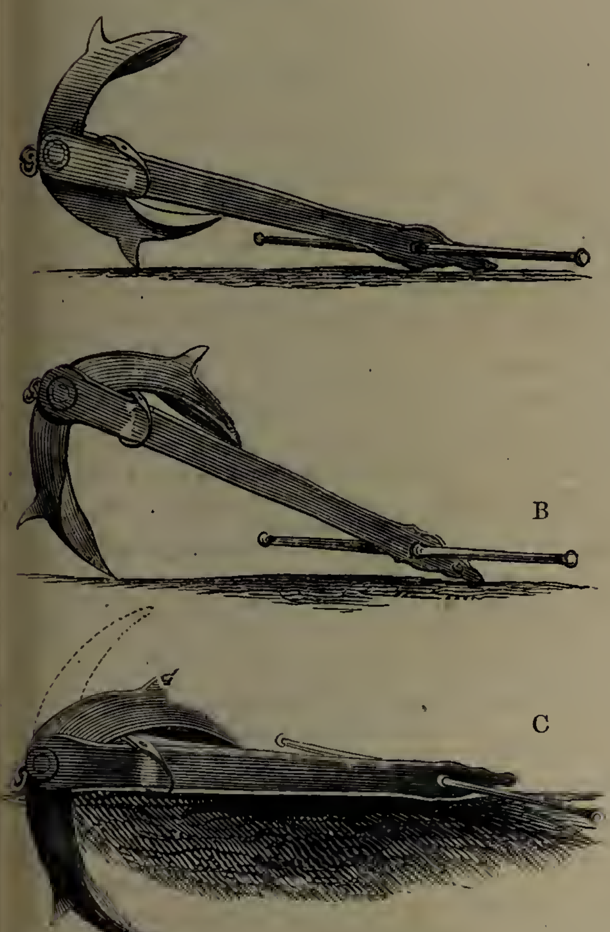
883.—Anchor.



890.—Marine Steam-engine Apparatus.

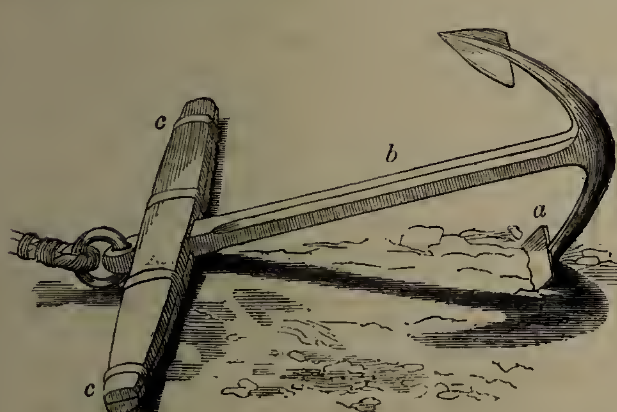


884.—Anchor.

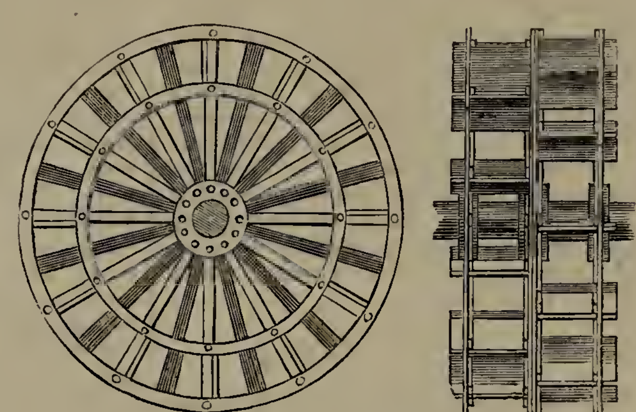


886.—Porter's Swivel-Anchor.

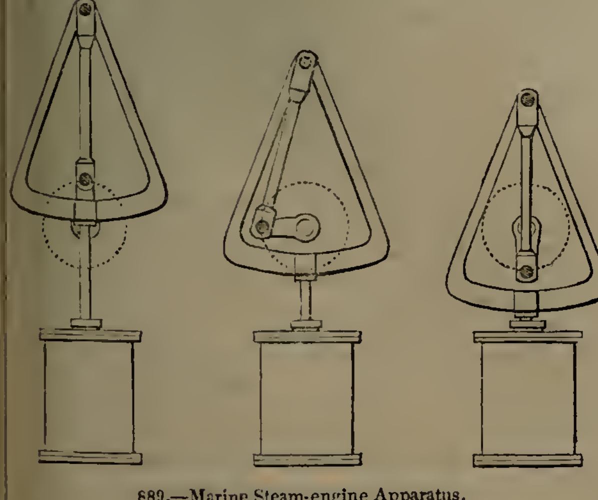
887.—Canal Viaduct at Pont-y-Cysylte.



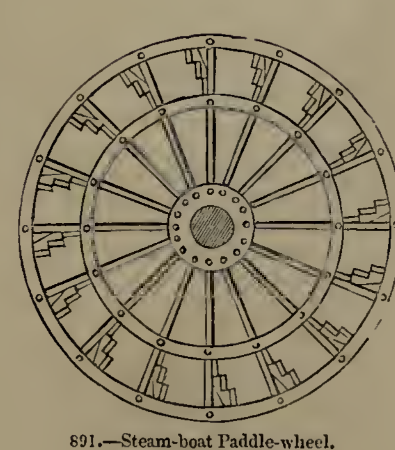
885.—Anchor.



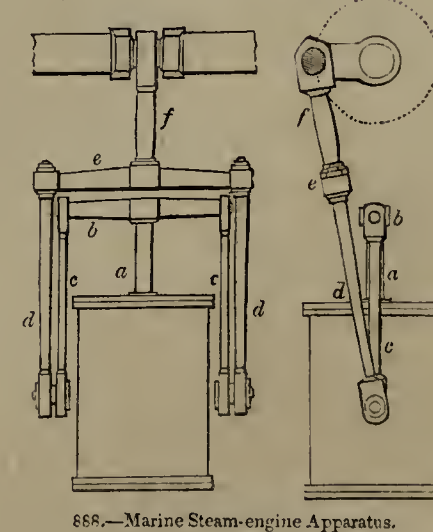
892.—Steam-boat Paddle-wheel.



889.—Marine Steam-engine Apparatus.



891.—Steam-boat Paddle-wheel.



888.—Marine Steam-engine Apparatus.

men has long been directed. Figs. 864, 867, will give two examples of this interior strengthening; the latter being the diagonal arrangement of the strengthening pieces, and the former the complex intersection of the whole when put together. At Fig. 865 we have a cross-section of a vessel; the left half of which shows one of the ribs with its interior and exterior casing; while the other half exhibits in addition the beams and strengthening timbers of the ship.

When the heavier parts are thus completed, the ship is lined within and without with planking, thin in comparison with the main timbers, but still of considerable thickness; the planks are made of oak, they are in some cases thirty feet long, and their thickness varies from three to six inches. As they are laid horizontally round the hull of the ship, and are required to conform to its curvature, they undergo a bending process before being fixed on. They are in the first place cut at the saw-pit pretty nearly to the right length, width, and thickness; they are then trimmed with an adze to give them the proper contour; and they are afterwards placed in an oblong trunk or case (Fig. 866) where they are exposed to the action of steam for several hours. Softened by this steaming, they are in a condition to be bent round the vessel, and kept close to the timbers by powerful screws and other instruments; every plank being so shaped as to fit closely to the one adjoining it; and all of them becoming narrower towards the ends than at the middle.

The mode of fastening these planks to the timbers is not among the least important of the arrangements. While the plank is being held up in its place by screws, a man mounts on a scaffold (Fig. 868) and bores holes with an auger; these holes are from one to two inches in diameter, according to the thickness of the planks, and are bored not only through the plank, but also through the main timbers and through the inner planking. The labour of boring them is hence very severe, especially near the keel, where the man has to work nearly over his head. Into some of these holes bolts of copper or iron are driven; but the greater number of the holes are allowed to remain open for some time, that the wood around them may season, and then large wooden pegs called "trenails" are driven in. These trenails are cut out of sound oak, either by machines or by men who work with sharp tools (Fig. 869), and are made from half a yard to a yard in length. Each trenail is slightly larger than the hole into which it is to be driven, so as to bite or hold firmly, and very powerful blows with a large hammer are required to drive it into its place: it is slightly longer than the depth of the hole, and the two ends are cut off after the driving. Finally, wedges are driven in at the ends, to tighten still more the trenail in the hole.

As a means of preventing water from entering between the planks, the seams are "caulked," or filled up by strings of "oakum." This oakum consists of old cables and ropes cut into pieces and picked asunder so as to form a mass of fibres; these fibres are rolled together as a kind of rude substitute for string, by means of the hand and a board placed in a sloping position (Fig. 870). The threads of oakum thus rolled are made up into bundles, and taken to the ship's side, where the caulker proceeds to use them. He drives in the threads by means of a hammer and an instrument called a "caulking-iron" (Fig. 874), filling up every seam so densely that it not only prevents the entrance of water, but also strengthens the framework generally. Any little rents, holes, or fissures that may appear in the woodwork are similarly filled up with oakum. After this the whole is coated with a hot mixture of pitch and resin.

The Decks—the Masts—the Sheathing.

While the main framework of the ship is thus progressing, many of the internal arrangements are also in hand. The decks, corresponding to the successive floors of a house, divide the internal area of the ship into compartments, one above another, and each deck is supported on one particular set of beams. We have explained, in an earlier page, that in a man-of-war there are three entire decks from end to end, besides two or three partial decks; but in smaller vessels the number is fewer, two whole decks and one partial deck being the utmost required in merchant-ships. Decks are generally made of fir, brought from Memel or Dantzic; the planks, varying from six to ten inches in breadth, and from two to four in thickness, are laid down parallel and fitted together with great nicety, the seams being coated with pitch and resin, to exclude wet. Besides the decks themselves, and the beams on which they are laid, there are numerous pieces of wood, called "partners," "coamings," and "carlings," placed at and around the various openings which are necessary in the deck of a vessel.

Without stopping to describe the multifarious arrangements connected with the ladders, the cabins, the berths, &c., all of which partake more or less of the character of joinery, we will pass on to notice those very important parts of a ship's fittings the *masts.* Whether there be three masts for a large ship, or two for a brig or schooner, or one for a sloop or smack, the mast is never (except for a very small vessel) formed of one single piece of wood: it is built up of two or more pieces raised one above another. Take the mainmast of a ship-of-war, for instance: this is formed, in fact, of three masts, of which the lowest is the "lower mast," the next in height the "top-mast," and the highest the "topgallant-mast." The length of the lower mast is generally rather more than that of the other two put together; and the entire length of the three exceeds in some vessels two hundred feet. In a large merchant-ship the lengths of these component parts of a mast vary from twenty to ninety feet; the longest being the lower-mast of the main-mast, and the shortest the "top-gallant" of the "mizen-mast."

Not only is each mast formed of three pieces in respect to length; but the diameter is often so great that no tree can be met with fitted to make it; and hence it is built up in thickness as well as in length. The principal part of the mast is made of Canadian fir; and the various pieces by which its bulk is made out are designated by the rather odd names of "spindles," "cheeks," "fillings," "cant-pieces," "heel-pieces," "side-trees," "front-fishes," and "side-fishes." All these pieces are shaped by means of the saw, the adze, and other tools; and are fitted together by various kinds of joints. So numerous are the pieces, and so bulky the whole mass, that (without going to the instance of a first-rate ship of war) it will be sufficient to state that the lower main-mast alone of an East Indiaman weighs upwards of six tons. As a means of retaining all the component parts in their right places, a number of stout iron rings are driven on the mast. These hoops are made of strips of iron bent round into a circular form, and welded; they are slightly smaller than the diameter of the mast, and are heated in a kiln previous to use; by the heating they are expanded, and in that state they are placed over the mast, and are driven on it in a very singular manner. Six men grasp the long handle of an iron bar, with which they strike the edge of the hoop on one side of the mast, while six others do the same on the other side with another bar; and two other men give powerful blows with hammers on the surface of the hoop. Signals are given to ensure regularity of movement, and the whole scene presents a singularly busy picture (Fig. 872). As the hoop contracts by cooling, it holds the mast together with enormous force.

The "bowsprit," the "yards," and the "booms" of a vessel are long spars, partaking in some respects of the general character of masts, though in a smaller degree. They are arranged in a ship in various positions, and serve to retain the rigging and sails in a proper position. The largest "yard" in the largest ship is a hundred feet long, by two feet diameter at the thicker end.

In fixing a mast into a ship there are two modes adopted; either by means of "sheers" or of a "sheer-hulk." Sheers is the name given to an arrangement of poles or spars built up on the deck of a ship, and meeting in a point over the hole where the mast is to be lowered into the hull of the vessel. The mast is floated to the side of the ship, elevated by means of tackle attached to the sheers and lowered into its place, where everything has previously been prepared for its reception. When one of the masts has been thus placed, the sheers are removed to other parts of the deck, and the other mast or masts fixed in a similar way. The other method is by the aid of a "sheer-hulk." This is an old worn-out ship, cut down to the lower deck, and provided with numerous masts, poles, ropes, and tackle, for hoisting great weights; these masts bend over one side of the hulk, so that their summits may be perpendicularly over the spot where a mast is to be lowered into another vessel. This latter is brought up to the side of the hulk; the mast is elevated by tackle to a sufficient height, and is then lowered into its place. In some places, as in the case of the East India Docks at Blackwall, there is a masting-house provided with similar means of lowering a mast into any ship placed beside it; but the general method of proceeding is much the same as in the other two modes; the object being to lift up the mast vertically to a sufficient height before lowering it into the hold of the ship.

The masts here spoken of as being lowered in this way are not the entire masts in their whole height, but only the first portion, called the "lower-mast," whether "fore," "main," or "mizen." The "top-masts" are not adjusted to their places till a later stage in the proceedings. The lower-mast is adjusted and secured in its place by shrouds and ropes of different kinds; and when thus fixed, the top-mast is raised upon it. The two, however, do not join end to end in the same vertical line, the top-mast being placed a little in front of the lower-mast. Near the spot where the two meet there is a horizontal platform called the "top," which has openings to receive the upper end of the lower-mast and the lower end of the top-mast; the two masts do not actually touch in any part, but both are secured firmly to this horizontal "top" and to the rigging of the ship. The "topgallant-mast," where there is one, is raised above the top-mast in a similar manner; another horizontal platform or "top" being placed at the junction of the two, as at the lower stage.

Another important feature is the *sheathing* of a ship, generally effected after it has been launched. This sheathing is a coating or envelope put over the whole external surface of the vessel exposed to the action of the water. Not only would the woodwork be liable to injury by such exposure, but so much ooze, sea-weed, and shells would attach themselves to the bottom, that the speed of the vessel would be materially lessened. Various means have been adopted of producing this sheathing. Planks of deal or fir, sheet-lead, brown paper coated with tar—all have been used at different times and in different countries for this purpose; but sheet-copper, or a mixed metal in which copper is one of the components, is found to be the best suited for this object. It was about sixty years ago that copper sheathing was first tried in the Royal Navy, and the result has been so satisfactory that all the best ships, whether mercantile or men-of-war, are now protected in this way.

The copper, or alloy of copper and zinc, is in the first place brought to the form of sheets, generally about four feet long by fourteen inches wide, having an average weight of about a pound and a half to the square foot. These sheets are nailed to the bottom of the vessel with nails made of the same metal; being sometimes nailed to the bare planking, and at others to an interposed layer of sheathing-board of felt or of paper previously coated with melted pitch and tar. The copper sheets are pierced with holes by means of a machine, not only all round the edges, but at intervals of three or four inches over the whole surface. The edge of each sheet laps about an inch over the adjoining sheet; and the flat-headed nails with which the whole is fastened are driven in regular order over the entire surface of the ship's bottom. Eight or ten thousand square feet of coppering are required for a merchantman of large size; and such coppering is worn out by an amount of work equal to two voyages to the East Indies and back. The chemical action of the sea-water, friction, concussion, and other causes, wear down a sixth or eighth part of the thickness of the copper in this time. The old copper is melted down to form new sheets for sheathing; and the new coppering is applied to the vessel in the same way as before.

The Rigging—Rope-making.

It would be useless to attempt a description of the exact order in which the building arrangements of a ship are conducted. The framework, the deck appendages, the interior fittings, the masts, the sails, the rigging, the anchors—all are in progress simultaneously. If a short sketch be given of each of these departments, all will be done that need be attempted here.

The "rigging" of a ship is a general name for the ropes, from the huge cable which draws up the ship's anchor by means of the windlass or capstan (Fig. 875) to the smallest lines connected with the sails. It is divided into two classes:—the "standing rigging," comprising "shrouds," "stays," "back-stays," and other ropes employed mainly in supporting the masts, bowsprits, and other fixtures in the ship; and the "running rigging," which comprises "braces," "sheets," "tacks," "haliards," "buntlines," and other ropes employed chiefly in working the sails. The standing rigging remains pretty nearly unaltered during the whole course of a voyage; but the running rigging is changed in position and action with every breath of wind, and every alteration made in the sailing of a ship. The standing rigging connects the ship with its superstructure of masts and sails; the running rigging governs its movements through the water.

All the ropes and lines which constitute the rigging of a ship are made of hemp, and nearly all are saturated with tar before being used. In the Government dockyards the ropes are made in buildings forming part of the general establishment; but in the private ship-building yards there are not usually the facilities for making ropes: other firms, devoted expressly to this branch of manufacture, make ropes of all the various kinds, and supply the ship-builders or ship-riggers with them. The most remarkable feature in every "ropery" or rope-factory is the "walk," a workshop exceeding in length any room in other departments of manufacture; it is generally from six to twelve hundred feet in length, being long enough for the manufacture of a ship's cable without a joint. In modern times machines have been constructed, on the ingenious plan invented by the late Captain Huddart, for making ropes without the necessity for this extreme length of building; but such ropewalks are a general characteristic of the manufacture.

A rope or string, whether large enough to raise a ship's anchor, or small enough to tie up a parcel, is composed of hempen fibres twisted one around another; and it is curious to see how a duplication and reduplication of this process leads to the production of a thick cable. Fig. 876 will assist us in understanding this matter. This is a piece of a large cable, dissected so as to show its component parts. In the first place, the individual fibres of hemp are twisted or spun so as

to form a small line or string called a "yarn;" then several of these yarns are twisted together to form a "strand;" three of these strands are twisted together to form what are called "hawser-laid" and "shroud-laid" ropes, or ropes fitted to serve as hawsers and shrouds; lastly, three of these ropes constitute a cable. In the figure, *a* is the cable, *b* the component ropes, *c* the strands, *d* the yarns, and *e* the individual hempen fibres. It is also observable that each twisting is in a different direction from that which preceded it, some being to the right and some to the left; a disposition which very materially increases the strength of the whole mass.

In making rope-yarns in the "walk," the hemp, after being "heckled," or straightened in its fibres, is tied round the body of a man (Fig. 877), in such a way that the ends of the fibres cross each other behind his back. He draws out the ends of a few fibres and fastens them to a hook attached to a wheel; he then walks backwards away from the wheel, giving out the hemp from his bundle as he recedes; while another man keeps the hook revolving by means of a handle. The effect of this double action is that a long line of fibres is gradually given off from the hempen bundle, and that this line becomes twisted into a yarn or string. Several hooks are attached to the wheel, and several men are generally making yarns at once, each yarn being twisted by the rotation of the hook to which it is attached at one end. The rate at which the man moves backwards, the velocity with which the hook revolves, the manner in which the fibres are drawn out of the bundle by the left hand of the workman, and the degree of pressure which he gives to them by a piece of thick woollen cloth held in his right hand—all take part in determining the kind of yarn produced. Practice enables a rope-spinner to make a thousand feet of yarn in twelve minutes.

When the yarns are twisted, they are wound up into bundles to be afterwards variously treated according to circumstances. For most land purposes, such as engineering or building, ropes are used in the "white" or "untarred" state; but for naval purposes they are generally "tarred;" and in the latter case the tarring is effected while the hemp is yet in the state of yarn. The yarns are collected into a larger group called a "haul," containing three or four hundred of them, and in this state are passed through a vessel containing melted tar; a subsequent pressure drives the tar into the innermost fibres of the yarn, and removes all the superabundant quantity.

In twisting yarns into a "strand" different methods are adopted, and different numbers of yarns used. All yarns are pretty nearly equal in thickness, about the sixth or eighth part of an inch: in some ropes there are only seven or eight of them in a strand, whereas in the largest cables for the navy there are upwards of three hundred. To twist these yarns together very ingenious machines are now employed. For the small sizes a kind of travelling carriage is used, which runs along a railway in a "walk;" this carriage contains revolving hooks, to which one end of each yarn is attached, and the rapidity of movement in these carriages is such as to cause all the yarns to twist round each other into the form of a "strand." For making larger strands Captain Huddart devised a very beautiful machine. The yarns are wound on bobbins, and these bobbins are placed in rows in a large frame or stage (Fig. 881). All the yarns from these bobbins pass through a perforated plate to a sort of funnel or tube, where they are collected into a group or roll, and this roll is twisted round into a hard dense rope by the revolution of a complex mass of machinery. The relation between the sizes of the various parts of this machine, and the rapidity of their revolution, determine the hardness or closeness of the twist; and it is one of the delicacies of this piece of apparatus, that every individual yarn is stretched exactly the same in degree as all the others.

When the strands are made, they are combined or "laid" into the form of a rope in a curious way. These strands are fixed to revolving hooks at one end of the ropewalk, and are made to twist round each other; but this twist would be too slight and unequal without other arrangements. The workman is provided with a conical piece of wood, called a "top," having three grooves along its surface; this "top" is placed in the middle of the three strands (Fig. 878), which fall into the grooves; and the strands are thereby prevented from twisting around each other, except near the smaller end or apex of the "top." The top and the carriage which supports it, as well as the workman behind it, all advance together as the rope is formed, and the man increases the hardness of the twist by means of a small piece of apparatus held in his hand. Whatever be the size of the rope, the strands which form it are twisted round each other; and in forming a cable from three such ropes, a similar plan is adopted, the scale of the machinery and general arrangements being dependent on the size of the rope or cable to be made. A machine of a vast and complicated kind was invented some years by Captain Huddart for making large cables, and some of these were supplied to the royal navy; but the increasing use of iron chain-cables has rendered the machine less valuable than it would otherwise be.

Many ropes, for mining and other purposes, are made flat instead of round; and these flat ropes are produced by sewing together smaller ropes side by side. A machine for effecting this has been invented by the same talented gentleman whose name has been so often mentioned. The ropes are wound upon reels, placed so that they may unwind and range themselves side by side. Two steel needles or piercers, threaded with hempen yarn (Fig. 879) are thrust alternately through the whole thickness of the ropes, by levers of immense power, and by this means the ropes are joined by what is in reality nothing more than a process of sewing by thread and needle, though on a very gigantic scale.

When the various kinds of cable, rope, and line are made by one or other of these several processes, the task of fitting them to their various places in a ship devolves on the "rigger." The "rigging-house" of a ship-yard is provided with tackle for stretching the ropes, with the necessary instruments for attaching blocks, rings, and other appendages to the ropes, and with means for fixing the ropes in their proper places to the ship. Some of the ropes being very large, the bending and adjusting of them require powerful instruments. Many of these ropes have an external envelope given to them in a remarkable manner. When a rope is likely to be exposed to much friction, it is bound round or "served" with a casing of smaller rope, intended only to shield but not to strengthen it; or, instead of smaller rope, other substances are sometimes employed, such as old canvas, mat, plait, or hide. In binding a smaller rope in this way round a large one, the workman employs a kind of mallet, having a concave groove opposite to the handle. This mallet is placed on the stretched rope; a boy holds a ball of the small rope near the man; some of the smaller rope is bound round the larger one and round the mallet; and the workman turning the mallet rapidly round the rope, causes the smaller rope or "service" to be wrapped spirally round it more densely and closely than it would be without the aid of the mallet (Fig. 880).

The Sails—Sail-making.

Like every other part of a large ship, the sails generally surprise by their vastness those who are accustomed only to land and its associations. Although the sails appear merely as large pieces of cloth extended to catch the wind, their size and weight are really very considerable. The main-sail alone of an East Indiaman contains seven hundred yards of canvas, while the whole set of sails for such a ship comprises not much less than nine thousand yards. As this canvas is woven with a width of only two feet, the making of a sail involves a good deal of sewing or seaming after the weaving of the material.

Sails are made from stout canvas of hemp or flax, generally the latter for the best ships. The flax is spun into yarn in Scotland, and brought to the sail-factories in large bundles, made up of small hanks; it has a brownish tinge while in this state, and undergoes a whitening or bleaching before being woven. It is steeped in hot alkaline solutions; stirred and beaten in a vessel containing water; rinsed in a stream of running water; pressed nearly dry by means of an hydraulic press; boiled for five hours in another kind of alkaline liquor; exposed for about a week to the bleaching action of the open air in a field; and thoroughly dried in a stove-heated room. This being completed, and a tolerable degree of whiteness attained, the yarn is prepared for being woven into canvas, either by the hand-loom or the power-loom, according to circumstances. The skeins of yarn are transferred to bobbins, and from the bobbins they are all brought into a parallel position on the yarn-beam of the loom. This process is, in some factories, effected by the aid of a machine which illustrates the comprehensive and time-saving arrangements of modern ingenuity. The bobbins are placed in a frame (seen at the left hand of Fig. 873), from whence the yarns unwind, and pass through an equal number of loops or eyes, to bring them parallel; they then dip into a trough of paste, and pass between two horse-hair brushes, which rub the paste well into the fibres of the yarn; after this, passing over two hollow metal boxes heated by steam they become thoroughly dried, and wind round the warp-beam in the proper order for weaving. By this admirable contrivance (the invention of which is due to the cotton-manufacturers of the north) nine hundred yarn-threads unwind from an equal number of bobbins, pass through all the stages of process here enumerated, and in a very few seconds reach the warp-beams in a thoroughly dried state.

The dressed yarn is woven into canvas about two feet wide; and this canvas, after being examined and measured, is passed through a calendering-machine, by which its surface is made smooth and glossy. It is finally made up into compact parcels, called "bolts," each of which contains about forty yards. The thickness of the canvas varies according to the purpose for which it is intended, and is estimated by the weight of the bolt; thus in the royal navy there are seven kinds of canvas used, designated from No. 1 to No. 7 respectively; and a bolt of the first must weigh forty-four pounds, whereas a bolt of No. 7 is only about half that weight.

When the sail-maker commences his operations he opens the "bolts," and cuts up the canvas into pieces suitable for his object. As some of the sails are rectangular, some triangular, some straight, and others curved, there is considerable art required in cutting up the canvas to the best advantage; and some of the canvas-cutters pride themselves in so adjusting the several pieces as to waste no more than three or four yards in a whole sail-suite of nine thousand. The cutting is effected by a knife inserted in a fold of the canvas, and not by scissors. The various pieces are sewn together by means of sewing-twine, used with three-cornered needles; the needles are of seven or eight different kinds, according to the work to be done; and the sewing-twine is rendered more durable by having been previously dipped into a melted composition of tar, grease, and oil, squeezed into the very heart of the fibres by pressure.

In sewing or making the sails, the workman seats himself on a kind of stool (Fig. 882), having by his side the few simple implements necessary for his purpose. He has on his palm a shield of grooved iron, intended to act as a thimble, and on his thumb another protector to enable him to draw the threads tightly. The two meeting edges of two breadths of canvas are made to overlap about an inch or an inch and a half, and a double row of stitches is made to secure them, having a closeness of generally about a hundred stitches to an inch. Besides the actual stitching of the different breadths of canvas to form a sail, there are numerous little appendages to be fastened to it for the sake of strengthening it in various directions, and of providing attachments for the ropes. The "bolt-rope," which is fastened to the edge of the sail all round to strengthen it, and which receives the names of "head-rope," "foot-rope," and "leech-rope," according as it is at the top, bottom, or sides of the sail, is first "served," or coated at its surface, and then sewn to the canvas, openings being left for rings, hooks, and other parts of the rigging.

Anchors—Chain Cables.

Next we come to those ponderous masses of metal which help to keep a ship stationary when required. Anchors, as is well known to everybody, have in general two arms or blades springing from a central stem (Figs. 883, 884, 885), and so formed as to dig deeply into the ground when fittingly placed for that object. Before the modern anchor was invented, large stones, baskets of stones, logs of wood loaded with lead, sacks filled with sand, and other contrivances were adopted; but nothing has been found so efficacious as the fluked anchor.

In various kinds of ships, placed under various circumstances, many forms of anchors are employed. Boats and small vessels employ *grapnels*, which consist of five or six hooks arranged round in a circle, so that one or other of them is pretty sure to catch in the ground. The *mooring* anchor used for securing vessels in a harbour is simply a very ponderous body lying at the bottom of the water, to which the ship may be attached by a rope or chain. An enormous block of stone, or several stones fastened together, or one of the very largest anchors after it has been disabled for other use, are often used for these purposes.

But the anchors properly so called are those which are carried in a ship, and are hurled out from her when the ship is to be brought to a stand. Several of them are carried in all ships of any magnitude; in a "first-rate" there are as many as seven; while in brigs and schooners there are three or four. The names of "sheet-anchor," "bower-anchor," "stream-anchor," "kedge-anchor," are given to the several anchors of a large ship, each having its own particular duty to serve. Some of these are of most enormous bulk and weight: the largest anchor for the largest ship weighs as much as 90 cwt., and generally costs the government somewhere about 300*l.*

The making of these ponderous masses is a remarkable branch of mechanical art,—one which has within the last few years received great advancement from the use of machinery. The several parts of an anchor are made separately, and then welded together; the shank, the arms, the palms, the ring—all being made of large masses of iron. In Figs. 883 and 885, *a* represents the arms, *b* the shank, and *c* the stock; but in Fig. 884 the analysis is more full: A is the ring, B the stock, K the arm, D*d* the throat, F the palm or fluke, B*b* the small, and H the bill or pea.

The shank, or long bar, which constitutes the main part of the anchor, is usually of such great thickness that no single bar of iron could produce it; and, therefore, in the common modes of anchor-making, it is built up of several smaller bars. For instance, in forging the shank for a large anchor, four iron bars are laid together in a group; on each side of this square are laid a greater number of smaller bars; outside these are others shaped something like the staves of a barrel;

893.—Snow-skating in Norway and Lapland.

894.—The Dog as a Beast of Draught.

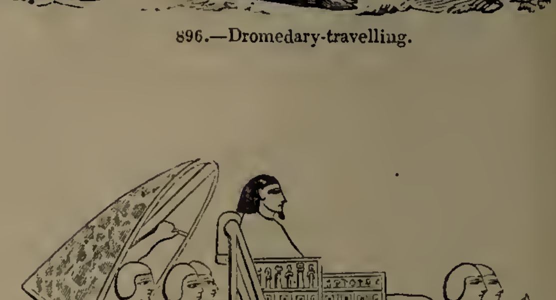
895.—Ostrich-travelling in Africa.

899.—Rein-deer Sledge.

900.—Esquimaux Dog-sledges.

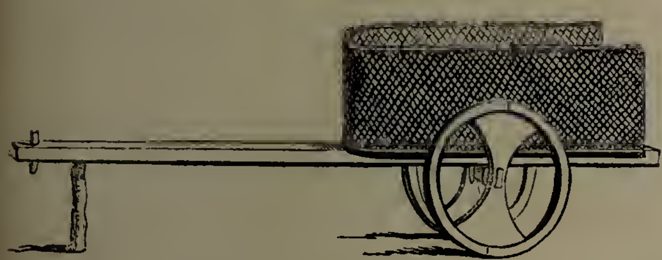
896.—Dromedary-travelling.

898.—Bullock Caravan in Moldavia.



897. —Ancient Egyptian Palanquin.

904.—Ox-Carriage of India.

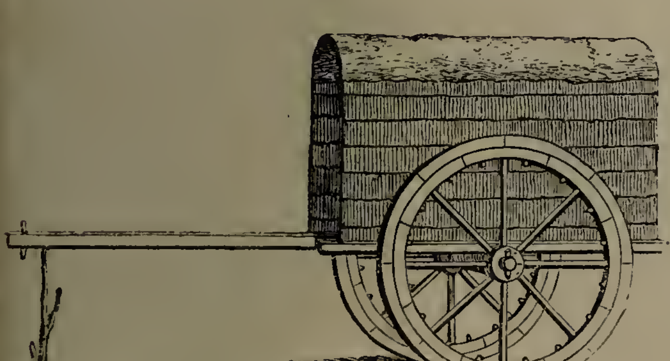


905.—Car of Portugal.

901.—Mule-travelling in Mountain-districts.

906.—Ancient Egyptian Car.

902.—Mandarin Courier of China.



907.—Ox-Cart of the Pampas in South America.

908—Chinese Palanquin-bearers.

903.—The J'Halledar, or State Palanquin of Hindustan.

and exterior to the whole are a number of hoops binding the mass together. Then the whole being brought to a white heat in a furnace, ponderous hammers are employed to weld them into one homogeneous mass. This process has something picturesque about it. The anchor-smith's hearth is so filled with coals or fuel as to envelope a part of the anchor-shank with flame and heat on every side: the shank is sometimes nearly twenty feet long, and as only so much of this is heated at once as can be welded before cooling, the fire is arranged so as to heat this portion only. After being exposed to a fierce heat for half an hour or an hour, the ponderous mass is drawn out of the fire by means of a crane, and placed with the heated part upon an anvil. Eight or ten men then range themselves round the glowing mass, and strike in succession with hammers weighing about sixteen pounds each; a fireman points with a rod to the spot where the blows are to be given, while another man is ready with a long bar to turn over the shank when necessary.

This was the old method of anchor-making, practised during the greater part of the last war; but many improvements have been subsequently introduced. The bellows for keeping up a fierce heat in the forge, instead of being worked by men as formerly, are now worked by steam. Instead of using six or eight hammers to give the blow, advantage is now taken of an enormous rammer, called a "Hercules," weighing five hundred pounds, and worked by ropes held by several men; a still greater improvement has been the adoption of a ponderous tilt-hammer worked by steam; and very recently a yet more powerful means devised by Mr. Nasmyth, and now employed in pile-driving, bids fair to be useful for this purpose.

A change in the mode of proceeding has also been adopted in reference to the building-up of the shank. When a thick shank is formed of numerous small bars, the heat cannot penetrate to the centre of the mass in the same degree as on the exterior surface; and it has often been found that the anchor is weakened by this circumstance. To obviate this defect, Mr. Pering some years ago devised a mode of making anchor-shanks, by laying broad bars one on another and welding them at two heatings; by which plan the separate pieces employed were much fewer in number. A later improvement, that of Lieut. Rodgers, consists in having the shank hollow, whereby less material is used, without lessening to any great extent, if at all, the strength of the mass.

Without detailing many minor improvements, it will be sufficient to mention the recent form of anchor devised by Mr. Porter. In anchors generally the palms or blades are arranged in a curved position at the lower end of the shank; and when hurled or let go from a ship, it pitches on the ground with the shank pretty nearly vertical; it presently falls over, however, and in so doing settles with the point of one of the palms downwards, in such a way that the latter can dig into the ground, and hold the vessel fast by the intervention of the cable to which the anchor is attached. In Mr. Porter's anchor, on the contrary, the two arms or blades are connected to the shank by a swivel, so that they can swing to and fro. The objects to be attained were principally these two: the avoidance of "fouling," or the passing of the cable over the exposed point of the anchor when fixed; and the avoidance of injury to the vessel itself in the event of falling upon her anchor. In anchors generally one fluke or point stands nearly upright when the other is immersed in the ground, and much mischief occasionally arises from this source. In the swivel-anchor, on the contrary, directly after it strikes the bottom of the sea, the swivel or hinge enables it to assume the position A (Fig. 886); the slightest movement of the cable suffices to disturb this position, and to bring it to the position B; lastly, the lower part, by penetrating into the ground, brings the anchor to the position C, with the upper peak lying out of harm's way on the shank, and not exposing a dangerous point as in the common anchor, as shown in the dotted lines.

But, whatever be the form of anchor, the process of "heaving," or drawing it up, requires arrangements of great magnitude and strength. When a rope cable is used, the circumference sometimes reaches the extent of twenty-five inches, and the anchor is weighed by means of a capstan, such as that sketched in Fig. 875; in which A is the cylinder of oak, strengthened by ribs or buttresses B; at C is the top, or drum-head, with holes, *a*, for receiving the ends of the levers by which the machine is turned round; and at *b* are paulls for preventing the cylinder from slipping round the wrong way.

An improvement in these matters has been introduced within the last few years by the use of "chain cables." The first incentive to the invention of these was the costliness of hemp during some period of the last war; but the excellence of the method, both as to charge and to efficiency, has led to its adoption on a very considerable scale. The liability of hempen cables to be destroyed, by chafing in rocky anchorage-grounds, sometimes occasions the loss of shipping; while the action of the sea-water upon hemp, and the alternate exposure to air and water, have a tendency to rot and weaken the fibres: these and other circumstances led to the suggestion of making cables of iron chain. It is said that the first idea of this occurred to M. Bougainville, during his voyage round the world, about eighty years ago; but that no attention was paid to the suggestion till after the commencement of the present century. In 1808 Mr. Slater, a surgeon in the Navy, took out a patent for a chain cable; and soon afterwards the Admiralty ordered a trial of them to be made in the Royal Navy. Since that time successive improvements have been made in the form and structure of the chains; and the use of them has now become very extensive.

The chain cables now made consist of links from two to four yards long, fastened together by bolts. The withdrawal of one of these bolts effectually severs the chain; and this affords an easier mode of slipping or throwing off the anchor, in case of necessity in a perilous sea, than by the labour of cutting through a large hempen cable. Every link and component part in a chain cable is tested separately as to strength, before being used. One of the most striking and truly commercial tests of the estimation in which chain cables are held, is afforded by the fact that a ship so provided can be insured on lower terms than if supplied only with hempen cambles.

CANAL AND STEAM-VESSEL TRANSIT.

WE have now glanced rapidly at what may perhaps be termed the alphabet of ship-building. We have seen what are the chief points connected with the ship-building art, as a branch of national government—the planning and architecture of a ship—the construction of the hull and framework—the materials and manufacture of the decks, the masts, and the sheathing—the general character of the rigging, and the mode of making ropes—the forms and the making of sails—the anchors and their manufacture—and the nature of a chain cable as distinguished from a hempen one. To go into details beyond this would scarcely comport with our object; for the minor matters in a ship, though incalculably numerous, belong for the most part to one or other of the groups above treated.

Before passing to canal and steam navigation, however, it may be well to say a word respecting the launching of a ship. The ship is built on blocks, declining towards the water at an angle of about five-eighths of an inch to a foot; and the means have to be devised for making the huge mass slide down this inclined plane. Two platforms or "ways" are built up, one on each side of the keel; and a large straight beam is laid, so as to slide down each of these platforms, grease or soap being placed between the rubbing surface. By means of a temporary framework and wedges the vessel is actually lifted from the ground, and supported on these two sliding beams, whose movement is checked until a particular movement. When the launching is to take place, the stops or shores are knocked away, and the sliding-beams glide down gently into the river, bearing their enormous burden safely into the sea or river.

Canal Transit.

The idea of forming an artificial channel as a substitute for a river, having a level surface instead of a flowing stream, is of ancient date. Canals were cut by the ancient Egyptians, both for the conveyance of goods and for purposes of irrigation. In China canals appear to have been one of the earliest evidences of civilization. The "Great Canal," in that country, is a memorable example of this class of engineering exploits. It is said to have occupied a hundred and twenty years in its construction, and to have given employment to thirty thousand men; occupying the entire of the fourteenth century. It is about a thousand miles in length, and is supplied by a great number of streams from the flat country through which it flows. Strong dykes, formed of alternate layers of earth and straw, and sometimes cased with stone, prevent the water from overflowing the flat country. In some parts the canal is carried on an embankment twenty feet high; while in others it traverses a cutting a hundred feet deep.

In America there are canals of great magnitude; such for example as that from Lake Erie to New York, which is four hundred miles in length. But the most remarkable of the American undertakings in this department is a railway and canal line from Philadelphia eastward: it commences by a railway, eighty miles long, from Philadelphia to Columbia; then a canal a hundred and seventy miles long; next another railway forty miles long; and, lastly, a second canal of a hundred miles—the lofty Alleghany mountains being crossed in the route.

The water-travelling in Holland is very remarkable, arising from the almost innumerable canals with which the country is intersected. These canals are navigated by boats called *trekschuits*, comprising each a fore-cabin for the humbler passengers, and a best cabin for those who pay higher. The latter, which will hold eight or ten persons, is fitted up with neatness, and is often hired by a party for their own exclusive use. The boat is drawn along by a towing-horse, which is ridden by a lad, whose duty it is to disengage the towing-rope when passing a bridge, and to lower and adjust the rope when two boats have to pass each other. The rate of charge is about a penny a mile; but the mode of conveyance has many inconveniences: it is very slow, not exceeding four miles an hour; it is often exceedingly monotonous, from the flatness of the country through which the canal passes; and it generally ends outside a town, instead of bringing the traveller pretty near the inn where he is to lodge. The boats start several times a day from almost every town in Holland, and are rigidly punctual as to the hour and minute. Another class of canal in Holland, arising out of the necessities of commerce, is the grand "Ship Canal," one of the finest specimens of canal-engineering anywhere exhibited. All ships which had to gain access from the German Ocean to Amsterdam had, before the construction of this canal, to pass into the Zuyder Zee; but this sea was so choked up with sand near the shores, that commerce was greatly impeded, and a canal was planned to give a direct outlet from Amsterdam to the sea. The canal was commenced in 1819, and finished in 1825; it is fifty miles long, a hundred and twenty-four feet wide at the water's surface, fifty-six at the bottom, and twenty feet deep: it receives its supply of water from the sea at high tides; and it is provided with two tide-locks at the extremities, two sluices with flood-gates, and eighteen drawbridges. The width of the canal has been so planned, and so far exceeds all that we generally look for in a canal, that two frigates can pass abreast!

All the various countries of Europe, with a few exceptions, exhibit canals to a greater or less extent. France, for instance, possesses the fine "Languedoc Canal," extending a hundred and fifty miles, from the Mediterranean to the Bay of Biscay. In Russia, the Baltic is connected with the Caspian by a chain of water-communication, formed partly of lakes, partly of rivers, and partly of canals. With respect to Sweden, the idea of forming a system of canal-navigation in that country, by connecting the different lakes together, occupied the attention of Swedish monarchs and engineers for many centuries. The object was to make a water-navigation between the Baltic and the North Sea; and a cataract at Trolhättan was the chief obstacle to the prosecution of this plan. All the other media of connexion were completed one by one; but it was not till the year 1832 that this last obstacle was finally removed. One engineer caused huge blocks of granite to be sunk immediately above the falls; into which, at vast expense, trees of the largest size were made fast; and so compactly were the massive materials united together, that the torrent became confined within half its former bed. But, being thus confined, it burst suddenly through the obstruction, and destroyed all that had been effected. A plan was then proposed of forming a new channel altogether at that part, thereby avoiding the cataract; and this plan, though one of immense labour, ultimately succeeded. The entire descent, of above a hundred and twenty feet, is effected by means of nine locks, five of which are cut through solid granite to the depth of a hundred feet.

The early history of canal-navigation in our own country, in connexion with the labours of Brindley, will occupy a little of our attention while speaking of other engineering matters in a future chapter. It will be sufficient here, as an example of what skill has wrought in this way, to refer to the aqueduct at Ponty-Cysylte (Fig. 887), by which the Ellesmere and Chester Canal is carried over the river Dee, at an elevation of a hundred and twenty-five feet above the bed of the river; the canal-course itself being formed, at this spot, of a cast-iron trough a thousand feet long, supported by nineteen pairs of stone piers from the valley below.

A few words about canal-transit, as distinct from canal construction:—

There are, it is computed, about 2200 miles of navigable canal in England, all of which have been constructed since the year 1760. Some of them have proved to be bad speculations; but a few of the best have turned out so well that their value in the market is (or was a few years ago, before the railway system became developed) worth twenty times the cost price; that is, a share in them was saleable at that proportionate advance. These canals intersect England in every direction, especially in and around the manufacturing counties. They have not succeeded, to any notable extent, in serving as media for travellers; but their availability for the transport of goods has been striking; and English industry owes much to them for its development.

As a means of showing how matters are conducted on the canals, let us watch the proceedings of one of the great carrying firms, such as that of Pickford and Co. The canal proprietors are paid by a toll of so much per ton on all goods carried on the canal. The barge of course makes up a notable portion of the whole weight, but this is not charged for; it belongs to the carrier, and the canal companies permit it to be brought on the canal on condition of being paid a tonnage toll on the weight of goods contained in it. The weight of each complete cargo is estimated in a singular but simple manner. When a new barge is brought upon the canal, it is accurately weighted and measured; and an entry is made of the depth to which it sinks, or

rather of the number of "dry inches" between the water level and a certain mark on the boat, with every quarter of a ton additional weight in it: these particulars, together with the number of the boat, are entered in a book; and whenever the boat passes a certain station on the canal, a rod is used to ascertain what is the number of "dry inches" with the particular cargo which she may then happen to have: on referring to a book it is seen what tonnage this corresponds to, and a charge is made accordingly.

The great firm mentioned above have about a hundred canal establishments in the country, all provided with a staff of clerks, porters, &c., as well as with waggons and horses, and all in communication with the central establishment in London. Supposing a cargo of goods has to be sent from a London warehouse or manufactory to Birmingham, and that it is to go by canal; and that other parcels are to be conveyed to Manchester, to Leeds, and other large towns. The waggons and carts of the firm are during the day employed in collecting these goods, and deposit them in a large wharf or warehouse at the City Road: there a thorough classification takes place; all the goods, from whatever quarters they may have been obtained, which are to go to one town are placed in one group; and the various groups are placed in barges according to their districts, each portion being weighed, registered, and ticketed separately. During the evening this busy scene of embarking takes place, and about midnight the barges set out, sometimes half a dozen in a party. Each boat is placed under the care of a "captain," who has three or four men and boys under him, for whom he is responsible; he receives a certain sum for navigating the boat a certain number of miles, out of which he pays his assistants: the barges, the horses, the fodder, all belong to the firm. When the "captain" has delivered his cargo to the several managers at the country stations, his task is done; the subsequent distribution of the goods being left to them.

Within a period of fifteen or twenty years, canals have been made available for passenger-traffic to a greater extent than they had been before; and were it not for the unprecedented advance of railroads, they would probably be a good deal employed for this purpose. In 1831 light passenger-boats were introduced on some of the canals in Scotland. They were about seventy feet long by five and a half broad, and carried from twenty to a hundred passengers. The hulls of the boats were formed of light iron-plate and ribs; and the covering was of wood and light oiled-cloth, so arranged that the passengers could be all under cover, and yet have an open space at the sides. The passengers, instead of being confined to one spot, had room to walk about. The fares charged were at the rate of a penny a mile for the best cabin, and three farthings in the second. Each boat was drawn by two horses; the tow-line being divided into two at the front end, and the horses attached one behind the other, the hinder one with a boy to drive the two. The horses were changed every four miles, after a run of from twenty to twenty-five minutes; and they made three or four stages a-day. When two boats were required to pass each other, the horses of one of them stopped just before they came up to the horses of the other, while the latter boat passes over the slackened tow-line of the former.

However, let the improvements of canal-transit be what they may, a gigantic power has been created which will pretty nearly confine canals to the conveyance of goods, and will even seriously lessen the amount of the latter. Most canal-boats, we may observe, are long and narrow, without any vestige of masts or sails; but some of the canal companies in the north, such as the Mersey and the Irwell, have boats with masts and sails, which are strong enough to stand the buffeting of the open sea.

Past Progress of Steam-Navigation.

As railways bid fair to lessen, year by year, the importance of canals, so do steam-vessels tend more and more to throw sailing vessels into the shade. The strenuous and bold assertions, made less than ten years ago, respecting the impossibility of crossing the Atlantic by steam, have been so utterly falsified by the result, that the word "impossible" is getting out of favour in such matters.

Without entering here into the history of the steam-engine, considered as a source of power generally, we may briefly trace the steps by which the power was made available for the transit of boats and ships.

Spain, which has done comparatively so little for science and art, has within the last few years put forth a claim to the honour of having invented steam-navigation. Among some of the royal archives of that country a manuscript has been discovered, which was published about twenty years ago, and which purports to be an account of an experiment made in 1543, which experiment was of the following character:—There was a vessel of about two hundred tons, containing something that looked like a cauldron of boiling water, together with two movable wheels at the sides of the ship; the vessels turned with promptitude and facility, but it consumed three hours in travelling two leagues, and was moreover both complex and expensive. Blasco de Garay, the inventor, received a reward from the king for his ingenuity; but nothing further is known of the matter. Considering the low state of the arts in Spain at that time, it is generally doubted whether such a machine, actually composed of a steam-engine, or something analogous to it, was really invented.

The honour has been also claimed for the Marquis of Worcester, an ingenious nobleman, who wrote a work called the 'Century of Inventions,' in the reign of Charles II. One of his inventions he describes as enabling him "to make a vessel of as great burthen as the river could bear, to go against the stream, which, the more rapid it is, the faster it shall advance; and the movable part that works it may be, by one man, still guided to take the best advantage of the stream." It is supposed (and the supposition receives support in other ways) that the Marquis had in view some kind of steam-engine as a moving power, but his description is too vague to give any definite idea on the matter.

Papin, in France, and Dr. Allen, in England, severally suggested the use of steam as a moving power for boats; but neither of them practically tested the plan. The same may be said of Jonathan Hulls, who in 1736 published a work on the subject; but he had the merit of entering much much fully on the subject. His work was a 'Description and Draught of a New-invented Machine for carrying Vessels or Ships out of or into any Harbour, Port, or River, against Wind and Tide, or in a Calm.' His proposal consisted in placing a steam-engine (then known by the name of an "atmospheric engine") in the tug-boat, and communicating the power by means of ropes to the axis of a kind of paddle-wheel mounted in a framework projecting from the stern of the vessel. He anticipated certain objections that might be raised to this plan, and explained the mode in which he proposed to obviate them.

Various other contrivances, originating both here and abroad, were brought forward during the last century, bearing more or less on this matter. In 1759 a Swiss pastor, named Genevois, proposed the adoption of a scheme founded on the action of the webbed foot of a duck; his plan consisted in the use of a kind of jointed oar or propeller, which should be expanded while actually propelling the boat, but should fold together, so as to pass through the water with very little resistance while being moved forward in order to make a fresh stroke. The propellers were to be worked by the re-action of springs; the springs being worked by a piston moving in a cylinder, and actuated by one of Newcomen's steam-engines. Another project was that of the Comte d'Auxiron, who appears actually to have made a small steam-boat, and to have tried it on the Seine in 1774; but the engine had not sufficient power to move the wheels properly; and some other parties resumed the experiment in the following year, with a modification of the arrangements.

Other French inventors, time after time, made various attempts in the same direction; all checked by difficulties of some kind or other. In America, too, projects were not wanting. Two individuals, named Fitch and Rumsey, made some progress in this matter about the year 1785: the latter made some short voyages on the river Potomac, with a boat about fifty feet long, propelled by the re-action of a stream of water drawn in at the bow and forced out at the stern by means of a pump worked by a steam-engine; the boat moved at the rate of three or four miles an hour when loaded with three tons in addition to the weight of her engine, which was about one-third of a ton; the boiler held only five gallons of water, and the whole machine did not occupy more space than five barrels of flour: the fuel consumed was from four to six bushels of coals in twelve hours.

The first parties in this country who, to a certainty, practically demonstrated the feasibility of steam-navigation, were connected with the northern cities of Edinburgh and Glasgow. In 1787 Mr. Miller, of Dalswinton, constructed a boat which was to be moved by paddles worked by men or horses; and having had his attention drawn to the possibility of using steam for this purpose, he availed himself of the services of Mr. Symington, an engineer of Glasgow, to put the idea to the test. The first experiment was, to use a double boat, containing a steam-engine on one side, a boiler on the other, and a paddle-wheel between the two boats: and this little contrivance was so far successful as to travel through the water at the rate of five miles an hour. The next experiment was in the large boats used on the Forth and Clyde canal, one of which was made to travel at the rate of seven miles an hour. As a commercial matter, these experiments led to no immediate result in England; for though Symington made a steam tug-boat for the Frith and Clyde Canal Company, it was not long employed; and it was not until 1813 that a steam-boat for passenger-traffic was permanently established on British rivers.

Meanwhile, whatever may have been the relative merits as to inventive powers, America had the credit of first plying steam-boats for hire. Fulton, after witnessing Symington's experiments in Scotland, constructed a small steam-boat for the Seine in 1803. Three years afterwards he commenced building a steam-boat on the river Hudson in America, which was launched in the spring of 1807; in the August of the same year the vessel started on her first voyage; and an eye-witness thus describes the effect produced on the bystanders:—"The minds of the most incredulous were changed in a few minutes—before the boat had made the progress of a quarter of a mile the greatest unbelievers must have been converted. The man who, while he looked on the expensive machine, thanked his stars that he had more wisdom than to waste his money on such idle schemes, changed the expression of his features as the boat moved from the wharf and gained her speed; his complacent smile gradually stiffened into an expression of wonder; the jeers of the ignorant, who had neither sense nor feeling enough to repress their contemptuous ridicule and rude jokes, were silenced for the moment by a vulgar astonishment, which deprived them of the power of utterance, till the triumphs of genius extorted from the incredulous multitude which crowded the shores shouts and acclamations of congratulations and applause." This vessel, the 'Clermont,' made her first voyage from New York to Albany, a distance of a hundred and forty-five miles, at a speed of five miles an hour.

This attempt of Fulton, in 1807, was the opening to the career of steam-navigation in America, where it has advanced year by year with great rapidity. Meanwhile, Mr. Henry Bell, who had been instrumental in obtaining information in Scotland for Fulton, put in operation a system of steam-navigation in the river Clyde. In 1813 he started a little boat called the 'Comet,' which plied as a passage-boat on the Frith of Forth. It was only forty-feet long at the keel, and about ten feet wide; its tonnage was about twenty-five tons, and it was worked by a little engine of three-horse power.

The problem once solved, both in America and in Britain, respecting the practicability of navigating rivers by steam-boats, a system of improvement commenced which has continued uninterruptedly to the present day. Mr. Scott Russell, after detailing ('Encylop. Brit.') the steps taken subsequent to Mr. Bell's successful attempt, says:—"The vessels were, however, of small dimensions, of low proportion of power, and of little speed, until the year 1818, when Mr. David Napier directed his attention to the improvement of steam-navigation. It is to this gentleman that Great Britain owes the introduction of deep-sea communication by steam-vessels, and the establishment of post-office steam-packets. In 1818 Mr. Napier established between Greenock and Belfast a regular steam-communication by means of the 'Rob Roy,' a vessel built by Mr. William Denny, of Dumbarton, of about ninety tons burden and thirty-horse power. For two winters she plied with perfect regularity and success between these ports, and was afterwards transferred to the English Channel to serve as a packet-boat between Dover and Calais. Having thus ventured into the open sea, Mr. Napier was not slow in extending his range. Soon after Messrs. Wood built for him the 'Talbot,' of one hundred and twenty tons. With two of Mr. Napier's engines, each of thirty-horse power, this vessel was in all respects the most perfect of her day, and was formed on a model which was long in being surpassed. She was the first vessel that plied between Holyhead and Dublin. About the same time he established the line of steam-ships between the stations of Liverpool, Greenock, and Glasgow."

It will be impossible here to follow out in detail the successive steps in the advancement of steam-navigation. It must suffice to say, that while these matters were pending in the north, attempts were from time to time made to introduce steam-transit on the Thames. It was about 1814 that a steam-boat first ran from London to Gravesend, at 4*s.* and 2*s.*; and about the same time a boat similarly ran from London to Richmond; but it was not till some years afterwards that these routes became established for steam-transit. But the greatest of all events in the history of the art was the successful passage of two vessels, the 'Sirius' and the 'Great Western,' from England to America in 1838; the first of which went from Cork to New York in nineteen days (April 4th to April 23rd); and the latter from Bristol to New York in fifteen days (April 8th to April 23rd). The subsequent misfortune of the 'President' steam-ship, and the abandonment of the 'British Queen' (Fig. 855) for this station, are fresh in the memory of most readers.

Steam-boats and their Arrangements.

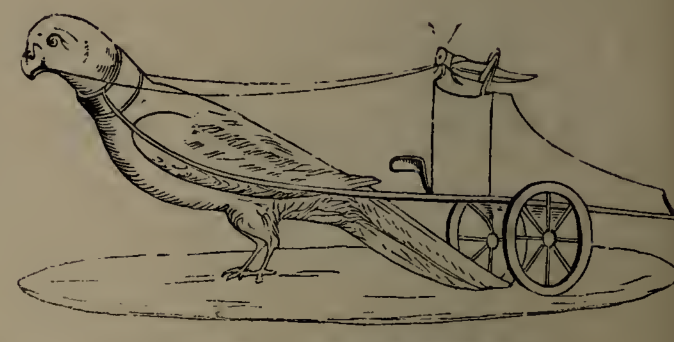
In the construction of a steam-boat of wood there are not many points of difference observable as compared with sailing vessels. In respect to shape, the former are longer and narrower than the latter; and in the arrangements of the keel provision is made for bearing the immense weight of the engines and boilers. It has been generally supposed that the unfortunate 'President,' whose fate is not known to the present hour, must have snapped in two in the middle, on account of the heavy pressure of the machinery on the middle of the keel; the vessel having been unprecedentedly long in comparison with the width.

One of the most notable features in the steam-boats

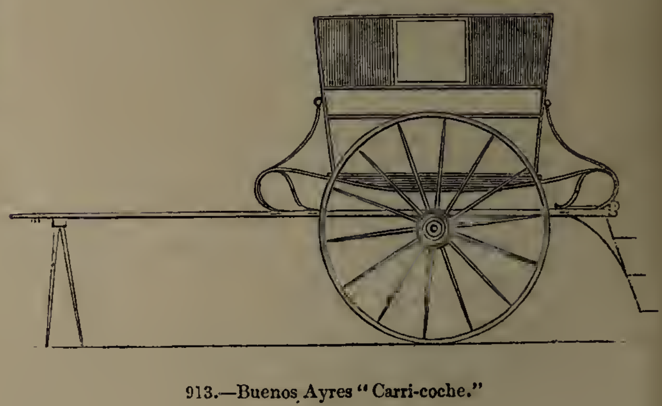
909.—Tatâr or Government Courier of Turkey.

910.—Ancient Egyptian Chariot.

911.—The Roads and Travelling arrangements in Japan.



912.—Bird-Chariot. (From an Arabesque at Pompeii.)

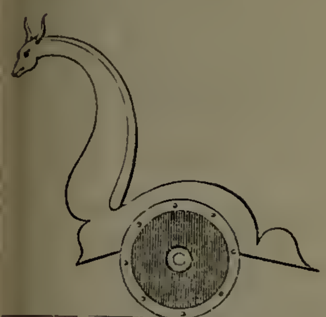


913.—Buenos Ayres "Carri-coche."

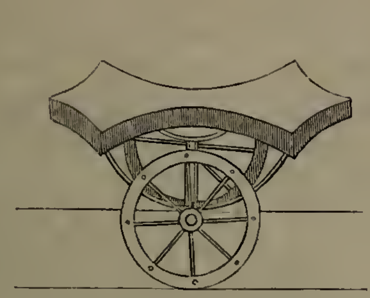
914.—Turkisk Arabah, drawn by Oxen.

915.—Sleigh-driving in Canada.

916.—Elephant-riding in the East.



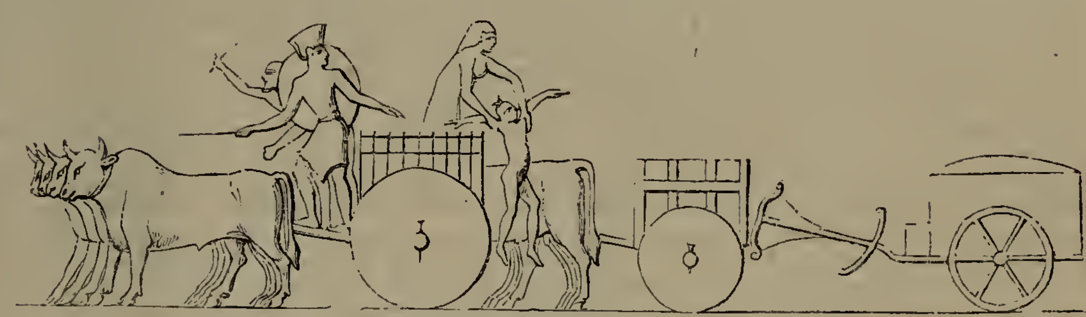
917.—Car. (From a Painting at Pompeii.)



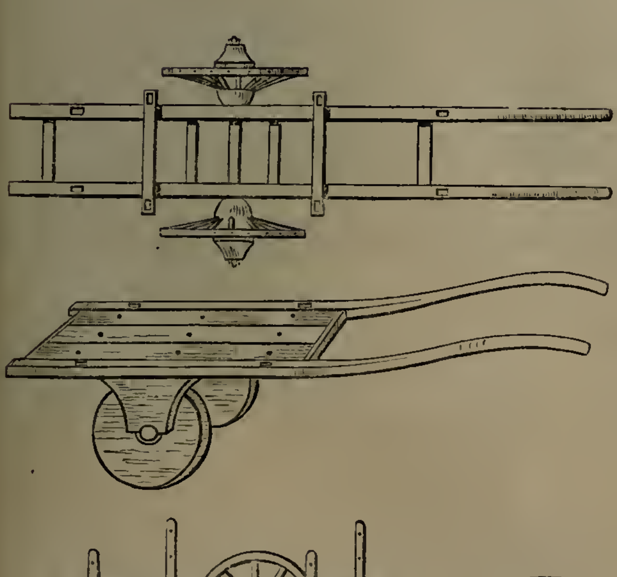
918.—Car. (From a bas-relief at Persepolis.)

919.—Caravanserai : Oriental Resting-place for Travellers.

921.—Welsh Agricultural Cart.



920.—Ancient Egyptian Carts. (From a bas-relief)



922.—Rude forms of Cart.

923.—Reindeer-Sledge travelling in the Arctic Regions.

of modern times is the use of iron instead of wood in the greater part of the construction of the hull. In a timber-built ship the keel, the ribs, the stem, the sternpost, and the planking, constitute the principal part of the hull, and are all made of stout timber; but in an iron vessel, the whole of these parts are made of that metal; and it is quite surprising to see the lightness and apparent slightness of the whole structure, as compared with the ponderous timber-built ship.

The keel of an iron vessel is formed of several pieces, bolted end to end in a very secure manner: it is by no means large in bulk, for a keel six inches deep by three in width will serve for a vessel of a thousand tons burden. There is a range of holes passing through the keel from side to side intended for the reception of rivets for fastening the various parts of the hull together. The ribs, instead of being vast beams, are merely iron bars, bent into the required curve, from the keel upwards. A bar of iron three inches square is sufficient to form the rib of a very large vessel; and even this is greatly reduced in weight by the hollowing out and removal of a good deal of the metal at one edge. The metal is brought to the exact form in a rolling-mill, where it passes between rollers grooved so as to give it the required section. Holes are bored in various places for the insertion of rivets; and the bars of iron, when prepared for use, are heated in a furnace, and bent round to the curvature of the hull. Each curved piece forms a rib, and is riveted very securely to the keel, the ribs being placed at a distance of about eighteen inches apart.

The outer surface, or what may be termed planking of the vessel, instead of being formed of oak planks, is made of sheet-iron, rolled to a proper degree of thickness into large sheets. These sheets are cut up by means of a powerful kind of shears or cutting instrument worked by steam, and have then a series of rivet-holes punched in them round the edges; they are bent into a curved form, and finally fastened to the ribs by means of numerous rivets. When the skeleton of the vessel is thus put together, the distinguishing points of difference between it and a timber-built ship are nearly at an end, for the interior fittings are much the same in both, and so also are the arrangements connected with the steam-engine and machinery.

The construction of the steam-engine for a ship is a different department of manufacture from that relating to the vessel itself, and carried on in different establishments; though there are some few firms which carry on both departments. The engine-work comprises an extensive series of mechanical operations, such as casting, forging, boring, turning, filing, rolling, punching, riveting, and many others; requiring the aid of great heat, a multiplicity of mechanical arrangements, and much practical skill. The cylinders, the boilers, the fire-places, the shafts, the pistons, the beams, the air-pumps, the wheels, the cranks—all are made separately, but as component parts of one whole. The "bed-plate," a large mass of iron on which the whole engine is supported in the hull of a steam-boat, is one of the largest single pieces of metal ever produced in our manufactures: it is sometimes nearly thirty feet long by about twelve wide, weighing from thirty to forty tons, and all cast in one piece.

A good deal of ingenuity is shown in the mode of adapting the action of the steam-engine to a vessel, so as to take up as little room as possible. The customary mode of arrangement is to have the beam or great lever below the level of the cylinder, and divided into two parts, one on either side of the vessel. A rod from one end of each of these half-beams is connected with a cross-piece at the top of the piston-rod, which is thus worked by them. The other ends of the double beam are connected by a cross-piece, carrying at its centre the mechanism which works the paddle-wheels. In all vessels of any considerable size there are two such engines, the power from both of which is communicated to the axis of the paddle-wheels.

Another arrangement has had for its object the communication of power at once from the engine to the paddle-axis, without the intervention of a beam or lever. One great difficulty to be surmounted is the small height available in the hull of a steam-vessel. In some small vessels the cylinders themselves are made to vibrate or oscillate, to afford a substitute for the action of a crank on the axis of the paddle-wheels. In another form of arrangement the cylinders are fixed, and the movement of the piston-rod is vertical, but they are surmounted by connecting-rods pivoted to them, which adapt themselves to the position of the cranks. Another modification is shown in Fig. 888, where the top of the piston-rod, *a*, carries a cross-piece, *b*, from which descend two rods, *c*, on either side of the cylinder; to these are attached two other rods, *d*, at the upper ends of which is another cross-piece, *e*; and from the centre of this a short rod, *f*, communicates motion to the crank-axle. A still further modification of arrangement is the adoption of the *steeple* engine (Fig. 889); in which the upper end of the piston-rod carries a frame of iron, which rises considerably higher than the paddle-shaft; the sides of the frame passing up on each side of the shaft, and being so far apart that the crank may turn freely within it; the connecting-rod descends from the upper part of the frame to the crank, and thereby imparts to it the motion of the frame and piston-rod. In the wood-cut the crank is shown in three different positions. A last variety of arrangement which we shall notice is that sketched in Fig. 890; where the connecting-rod, *a*, proceeds from the crank to a pivot attached to the piston; and the lateral movement required to enable it to accommodate itself to the movement of the crank is provided for by a case or barrel, *b*, attached to the piston, and sliding up and down with it through a steam-tight slit in the head of the cylinder.

All these arrangements refer to the various modes of communicating motion from the piston in the cylinder to the axis which connects the paddle-wheels. The paddle-wheel is sometimes formed as in Fig. 891, where the float-boards extend across the whole width of the wheel; but each of them consists of two, three, or more narrow strips, placed a little in advance of each other, so as to strike the water at slightly different times. Another form is that shown in Fig. 892; in which the float-boards, instead of extending the whole width of the wheel, are in two or sometimes three sets, each of which extends across only one-half or one-third of the width; one set of float-boards being placed opposite to the intervals of the other set. Generally speaking, however, the original or common paddle-wheel, with undivided float-boards, is more employed.

The Americans are famous for a sort of recklessness in their steam-navigation; that is, the employment of steam at such a high pressure, and the attainment of such a high rate of speed, as would rather alarm English travellers. It is only fair, however, to say that there are other and more agreeable features observable. As they have to navigate rivers free from the roughness of the open sea, the American steamers are made more roomy, but drawing less depth of water, than English steamers. The engines, and nearly all the mechanism connected with them, are on deck. There was a large vessel, the "Carroll of Carrollton," of which a description was given in the public journals about twelve years ago, and which will afford a good idea of the American steamers.

The helmsman's station was in the fore part of the vessel, in a little covered recess, with his compass before him, and strings near his hand to communicate signals to the engine-man behind him. The services of the boys, who in the Thames steamers are eternally bawling out to the engine-man to "ease her," or "stop her," or "put her astern," were thus dispensed with. The fire for the engine was kept up by billets of wood instead of coal or coke. On deck was the captain's office for receiving fares and transacting other business; there were also a post-office; a hair-dresser's shop with all the arrangements for cutting and curling; a stall for cleaning shoes and brushing clothes; with luggage-cabin and other offices. There was a kind of awning-deck, under which the passengers might shelter in wet weather, or upon which they might sit or promenade when it was fine. Below stairs the cabin accommodation was very superior; since, the whole of the machinery being upon deck, there was nothing to interrupt the continuity of the cabin. The sleeping-berths, too, appear to have had a degree of roominess and comfort not always found in English steamers. The ladies' cabin contained a pianoforte, loo-tables, and all the luxuries of drawing-room furniture; and there was at hand a circulating library, from which books of novels, histories, and biographies were lent out to read during the voyage for a trifling sum.

Perhaps there could not be a more appropriate ending of the present chapter than a slight notice of that mighty specimen of steam-ship engineering, the '*Great Britain*,' which is proceeding on her first voyage to America while this sheet is passing through the press. This vessel is 289 feet long at the keel, and 332 total length; the greatest width 51 feet, and the depth 32; it displaces 16 feet of water when laden; its tonnage is 3443 tons; the sheet iron with which the water-surface is formed varies from half an inch to an inch in thickness; the boilers, weighing 200 tons, and capable of holding 200 tons of water, are supported upon ten cast-iron beams, or girders, more than three feet in depth; the power is 1000-horse; the engines weigh 340 tons; the main shaft is upwards of 24 inches in diameter; the vessel is propelled by a screw instead of paddle-wheels, the screw having six arms, 15½ feet in diameter, 25 feet pitch, and weighs four tons; there are five water-tight partitions in the hull; there is stowage for 1500 tons of coal; there are four cylinders to give the working power, each of 88 inches diameter, and having a stroke of six feet.

In respect to the sailing arrangements, this mighty vessel has six masts, fitted with wire-rope rigging; and it is provided, among other fittings, with the new "swivel anchors" alluded to in a former page. The passenger-accommodations are on a scale compatible with everything else. There are no less than two hundred and fifty berths, arranged round two complete decks.

If this vessel, in respect to safety and speed (for commercial success depends on many points beyond the reach of the ship-builder), should equal the expectations of the owners to the same degree as her predecessor the '*Great Western*,' she will indeed be a fortunate vessel. From 1838 to 1844 that ship made seventy passages across the Atlantic, comprising a distance of 256,000 miles. The average speed of the outward journeys was 9½ miles an hour, and of the homeward 11¼ miles (the difference being due to the effect of the "gulf-stream" in the Atlantic, which retards the outward voyage and hastens the homeward). The shortest outward passage was 12 days 18 hours; and the longest (in stormy weather) 22 days 6 hours. The shortest homeward voyage was 12 days 7 hours; and the longest 15 days 8 hours. The average for the whole of the outward trips was 15 days 12 hours, and for the homeward 13 days 9 hours. The distance of each voyage was rather more than 3000 miles. The greatest number of passengers taken at once was 152.

These are indeed mighty exploits, especially when we consider how little had been done towards deep-sea steaming twenty years ago! One hardly knows whether most to admire the marine engine or the locomotive in bringing distant countries together, and setting at nought time and distance. It was remarked four or five years ago (Penny Magazine, No. 533), that "the alliance of steam with the press, the ship, and the railway-carriage, is a power which has only been introduced into the world within the recollection of the present generation. Can there be a doubt of the vast influence which this triple connexion must exercise upon the future destinies of mankind; or is there a more magnificent subject for speculation than the triumphs of civilization and knowledge which will be the result of this confederation of the highest elements of social progress—knowledge, commerce, and the facilities of intercourse—over all the kingdoms of the earth? Is a barbarous country like Africa to be raised from the moral darkness which overshadows its vast surface,—what more potent agent for effecting this object than the steam-ship, which carries the white man into the heart of the country, and renders the great rivers by which he penetrates the tributaries of religion, peace, and commerce?"

CHAPTER VI.

THE ARTS RELATING TO VEHICLES AND LAND-TRAVELLING.

In glancing over the usages of different nations at different times, in respect to the modes of travelling on land, and the arts contributary thereto, we can scarcely fail to see that War and Agriculture were the two purposes to which such arrangements were first applied. The war-chariots of early times are among the very earliest kinds of vehicles of which we find any mention; while the use of oxen at the plough seems to have been the primitive mode of applying such arts to peaceful and useful pursuits.

But whatever may have been the priority as to vehicles, there are many reasons for thinking that *riding*, as distinguished from *driving*, was the earlier mode of travelling, properly so called. The horse and the camel, two of the most precious and indispensable animals that nature ever placed at the disposal of man, are found abundantly in those regions which were first peopled; and as both animals, from their physical confirmation, are capable of bearing burdens on the back, the use of them in rapid travelling could scarcely escape the notice of tribes who were often placed under the necessity of migrating in search of new pastures or new centres of intercourse with other tribes.

Before treating of vehicles, and the arts relating to their construction and use, it may be well to speak briefly of the use of various animals as substitutes for the horse in travelling: leaving the latter to be regarded in connexion with vehicles generally.

MODES OF TRAVELLING IN RUDE COUNTRIES.

There are many countries in which travelling, understood in the usual sense, is rather an accidental circumstance than a custom, since the inhabitants are too poor or too rude to have established any system of such a kind. Not only have they made no progress in the construction of vehicles, but the training of animals to purposes of docile industry is almost unknown by them. Many tribes in the heart of Africa, for instance, and in the Polynesian Islands, are so situated.

For the most part, however, the art of applying animal power in this way is known and practised under one or other of its several forms. The horse, the mule, the ass, the ox, the camel, the dromedary, the reindeer, the dog—all are employed in this way. Even the ostrich is sometimes applied to a similar use. With respect to this latter-named and remarkable animal, its natural rate of motion when at the swiftest, is said to exceed that of the fleetest horse; and the Africans can only run them down by a combined system of operations lasting for two or three days together. Occasionally the Africans journey on the back of an ostrich (Fig. 895); and Adamson, speaking of two tame ostriches kept at a station on the Niger, says: "They were so tame, that two little blacks mounted together on the back of the largest: no sooner did he feel their weight, than he began to run as fast as ever he could, till he carried them several times round the village, and it was impossible to stop him, otherwise than by obstructing the passage. This sight pleased me so well that I would have it repeated: and to try their strength, I made a full-grown negro mount upon the smallest, and two others the largest—this burden did not seem to me at all disproportioned to their strength. At first they went a moderate gallop; when they were heated a little, they expanded their wings as if it were to catch the wind, and they moved with such fleetness that they seemed to be off the ground."

Carrier-pigeon Travelling.

Perhaps the most rapid of all travelling is that performed by the carrier-pigeon. The recorded instances of this enormous rapidity are too well authenticated to admit of doubt. For instance, in 1804, a carrier-pigeon flew from Paris to Cologne at the rate of a hundred and fifty miles an hour. Audubon was able to prove that a variety of American pigeons, heavier than the carrier-pigeon, could exceed a mile a minute in its rate of travelling. Pigeons have been known to travel from Babylon to Aleppo (thirty days' journey for camels) in forty-eight hours. Pigeons have been killed at New York with the crops full of undigested rice; as their digestion is so good that they decompose food entirely in twelve hours, and as no rice-grounds are found nearer to New York than Georgia or Carolina, it is inferred that such birds must have travelled three or four hundred miles in six hours—a velocity, as has been well observed, which would enable one of these birds, were it so inclined, to visit the European continent in less than three days; a feat which no 'Great Western' has yet been made to accomplish.

It is still a disputed point how these animals are enabled to find their way such immense distances. Mr. Rennie thinks that their extraordinarily acute eyesight is their main instrument. He says, "On being let go from the bag, in which they have been carried in order to conceal from their notice the objects on the road, they dart off on an irregular excursion, as if it were more to ascertain the reality of their freedom than to make an effort to return. When they find themselves at full liberty, they direct their flight in circles round the spot whence they have been liberated; not only increasing the diameter of the circle at every round, but rising at the same time gradually higher. This is continued as long as the eye can discern the birds; and hence we conclude that it is also continued after we lose sight of them, a constantly increasing circle being made till they ascertain some known object enabling them to shape a direct course."

Mr. Thompson, in his recently-published 'Note-book of a Naturalist,' gives a curious illustration of the commercial value of pigeons as locomotive agents:—"The system of communication by means of carrier-pigeons, between London and Paris, is carried on to a very considerable extent and at a great cost. There are several perfect establishments kept up by parties interested in the quick transmission of intelligence, at the ports of Dover and Calais, and at regular distances on the roads of the two countries; whence the birds are exchanged in regular order as they return with their little billet. The interruption occasioned by the hours of night is made up by a man on horseback; who again at daylight, on arriving at a pigeon-station, transfers his despatch to the keeper, who has his bird in readiness. The distance by day is accomplished in less than eight hours. It has been found that hawks have proved themselves dangerous enemies even to these quick-flighted birds; and a premium of half-a-crown is paid for every hawk's head produced. The pay of a keeper is 50*l.* a-year; and when this is added to the cost of food and the expense of sending the pigeons on from station to station to be ready for the flight home, it will appear that the service is attended with considerable outlay. The duty of training young birds, and the management of the old ones, in feeding them at proper times, and in keeping them in the dark until they are thrown up, is very responsible, and almost unceasing. A good bird is not supposed to last more than two years."

Snow-skate Travelling in Lapland.

It is, perhaps, scarcely consistent with common usage to speak of *skating* as a mode of travelling. Yet there are circumstances under which it certainly seems to claim such a notice. In this country skating is merely an amusement—the variety known as "figure-skating" being much more studied than the swift progress denominated "running." There are examples, however, which show that an extraordinary rate of speed is occasionally attained by English skaters, especially in the fenny districts of Lincolnshire and Cambridgeshire. In 1820, instances there occurred of a mile being accomplished in very little more than two minutes. One celebrated skater could skate a mile in a minute and four seconds; another skated two miles in three minutes and eight seconds. In the winter of 1838, two skaters went from Ely to Cambridge and back, in all forty miles, in two hours and thirty-six minutes.

In some of the northern countries of Europe, however, skating is an important means of travelling in severe winters, and as such is much valued. In Holland, when the canals are frozen over, the inhabitants, both male and female, mounted on skates, glide along with amazing velocity, often carrying heavy burdens on their heads.

But one of the most remarkable kinds of skating is the *snow-skating* of Lapland. In that bleak country a snowy surface is much more common than a smooth icy one; and the inhabitants adapt themselves to the existing state of things. The skate or snow-shoe worn by them, called a "skie," is a flat piece of wood, very narrow, but six or seven feet in length, with a fastening for the foot on the middle. Sir Arthur de Capel Brooke describes the use of these skates very minutely:—"As soon as the snow falls, the Laplander puts on his snow-skates, though it is not till the surface of the snow has acquired a certain degree of hardness that he can proceed with any speed. In northern countries, after the snow has fallen a few days, the frost gives it such a consistence that it is firm enough to support the weight of a man; the surface becomes hard and glazed; and the Laplander can then make his way, in any direction he pleases, across the country which was before impassable. Nothing is capable of stopping him, and he skims with equal ease and rapidity the white expanse of land, lake, and river. His address, however, is most remarkable in the descent of the mountains and precipices of Finmark, which to any eye but his own would appear impassable. From the length of the *skie*, it might be thought extremely cumbersome; its weight, however, from the lightness of its materials and its narrowness, is not great; and the skater moves forward with facility, merely gliding on, without raising it from the ground. In many parts of Lapland, the greatest use of them is in the pursuit of wild reindeer and the other animals with which the country abounds. When the Laplander sets out in the pursuit, and comes to a mountain, the summit of which he wishes to gain, however steep the ascent may be, practice enables him to surmount it with comparative ease, though the operation is necessarily the slowest, requiring considerable address to prevent the smooth surface of the skate from slipping, and precipitating the wearer backwards. To obviate this the Laplander sometimes covers the *skie* with reindeer or seal skins, the hair of which, being turned backward, hinders it from a retrograde direction. In ascending the sides of mountains he is of course obliged to proceed in a zigzag direction, and although the ascent should be long and steep, he accomplishes it in a surprisingly short time, considering its difficulty. When, however, he arrives at a part which he intends to descend, it is very different. Sometimes the lofty ranges are many miles from the summit to the base, consisting of long precipitous declivities, frequently obstructed by large masses of detached rock, and in others presenting a smooth and steeply-inclined surface, with many windings. When the Laplander begins the descent, he places himself in a crawling posture, his knees bent, and his body inclined backward to assist him in keeping his position; he holds in one hand a staff, which he presses on the snow, and which serves also to moderate his speed when too great. In this manner he will shoot down the steepest declivities. So great is his dexterity, that if he should meet suddenly with a fragment of rock, or other impediment, he takes a bound of some yards to avoid it; and such is his velocity, when the part is very steep, that it may be compared to that of an arrow, a cloud of snow being formed by the impetus of his descent."

Fifty miles a day is a common rate of travelling with these snow-skates; and the great facility afforded by such a velocity of movement has led, in Norway, to the formation of a military corps, called the *Skielöbere*, or "Skate-runners." These men learn to acquire great dexterity in the use of the *skie;* and their power in harassing an enemy in the field is said to be very great, for they can pass with safety over snow much too soft for either cavalry or infantry; while their velocity of movement prevents any good aim from being taken at them by artillery. The manœuvring and descent of a hill by the skate-runners are illustrated in Fig. 893.

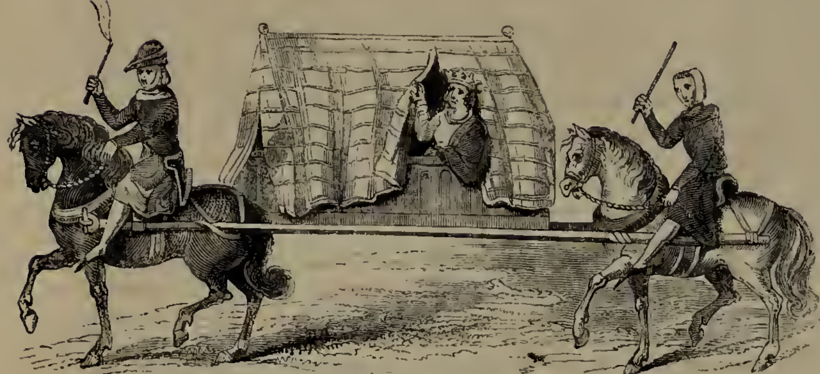
Elephant-riding in the East.

The use of the elephant for riding, and also for drawing burdens, is much known in the East; and many

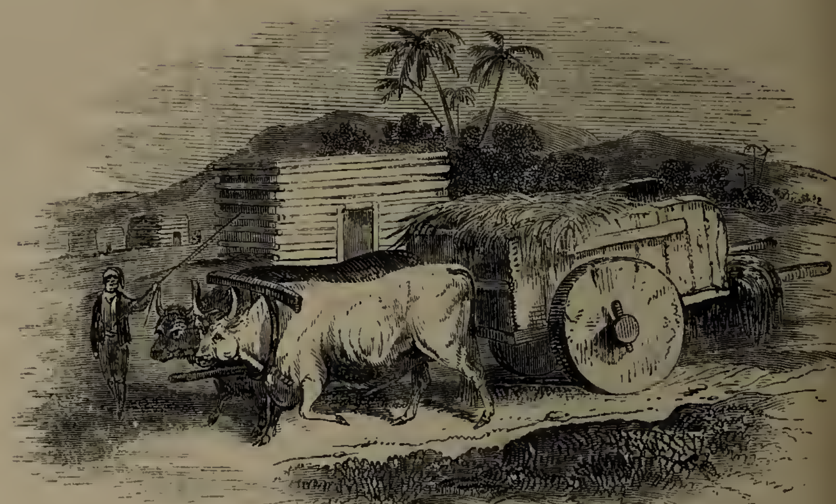
924.—Camel-travelling in Arabia.

925.—Saddle-Ass of Egypt.

926.—Cart and Roadway. (From a Painting at Pompeii.)

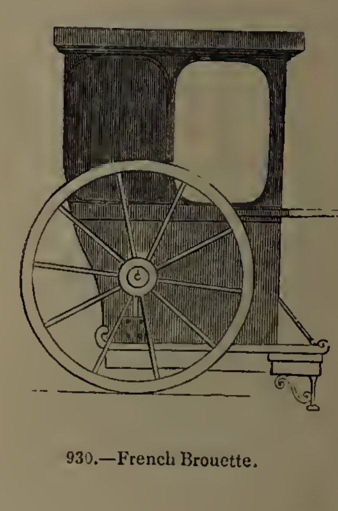


927.—Two-horse Litter : Fourteenth Century.

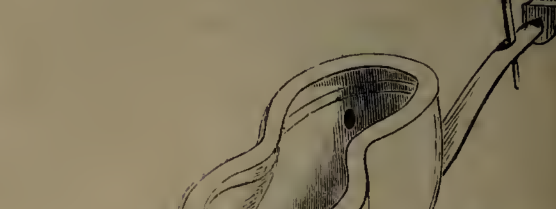


928.—Syrian Ox-Cart.

929.—The Neapolitan Calesso.



930.—French Brouette.



931.—Chariot. (From a Paintin a Pompeii.)

932.—Travelling in Russia.

34.—Yarmouth Beach-Cart, for conveying Fish from the Boats.

935.—Italian Coach, of the Sixteenth Century.

936.—English Sailors in a Maltese Calesse

European travellers have given descriptions of the arrangements connected with these employments of the animal.

Bishop Heber says that when at Barrackpoor he first mounted an elephant, the motion of which he thought far from disagreeable, though very different from that of a horse. As the animal moves both feet on the same side at once, the sensation is like that of being carried on a man's shoulders. A full-grown elephant carries two persons in the howdah or carriage, besides the driver or "mohout," who sits on his neck, and the servant who sits behind to hold an umbrella over the rider's head. The howdah is often very much like the body of an English gig without the head. Another writer, Captain Williamson, spoke less favourably of the sort of movement than Bishop Heber. He says that the peculiar gait of the elephant is so fatiguing as scarcely to be borne for any considerable distance. Indeed he says, "I know nothing more uncomfortable and tedious, I may even say painful, than a long journey in a howdah; it occasions a lassitude not to be described. We must suppose that habit reconciles persons to it, as we see the natives travel, for perhaps twenty miles or more in a forenoon, without any apparent uneasiness. The largest elephants are in general the most uncomfortable in this respect."

The use of the howdah is not invariable in elephant-travelling. Some of the smaller animals are ridden with a saddle and stirrups. Others have a pad, on which six or eight men can ride, some astride, and others sideways. In mounting an elephant, the animal kneels down; a man puts his foot upon its fore leg, to prevent it from rising too soon; a ladder is placed against the animal's side, and the rider mounts to the howdah by such means. Some of the Orientals, however, pride themselves on a more manly way of gaining access to their seat on the elephant's back. Crawford, after describing a spectacle at which the king of Ava was present, and the preparations for his departure, says, "His elephant, one of the noblest animals I have ever seen, having the trunk, head, and part of the neck of a white flesh-colour, and in other respects altogether perfect, was brought up close to the shed under which we were sitting, and mounted it with great agility, placed himself upon the neck of the animal, took the hook in his hand, and seemed to be perfectly at home in this employment. We afterwards saw the heir-apparent, a child of thirteen years of age, guiding his elephant in the same way. This practice is, I believe, peculiar to the Birmans; for, in Western India at least, no person of condition ever condescends to guide his own elephant. There is, at least, some manliness in the custom; and I should not be surprised to find that the neck of the elephant would be found, on experience, the most agreeable and easy seat to the rider."

At the present day the elephant is not employed so much in travelling as formerly. When so employed, his services are in requisition rather for carrying tents, and the multitudinous articles of tent-furniture, than for stately riders. In time of war, however, their aid is very valuable. In the Anglo-English armies of Hindostan every officer has with him a considerable number of servants; the camp-followers are amazingly numerous; and the stores of every kind taken with the troops are most varied and bulky; so that the animals required for conveying them must necessarily be great in number.

One of the most striking uses of the elephant in an Indian army, in respect to travelling arrangements (the only point which we have to do with here), is in the conveyance of artillery. The best roads are sometimes suddenly broken up by violent rains, and then they present a succession of deep ravines with clayey banks, on which bullocks have a very insecure footing. The artillery cannot pass without the aid of the elephant. To every battering-train a few of these animals are attached. They always apply their strength in the most efficacious manner, either in pushing forward the guns with their foreheads, or lifting them up with their trunks when the wheels have sunk into a deep rut or slough. Captain Williamson has more fully described their services in this particular:—"Many of our arduous military operations have been greatly indebted for their success to the sagacity, patience, and exertion of elephants. Exclusive of their utility in carrying baggage and stores, considerable aid is frequently supplied by the judgment they display, bordering very closely on reason. When cannon require to be extricated from sloughs, the elephant, placing his forehead to the muzzle, which when timbered is the rear of the piece, with an energy scarcely to be conceived, will urge it through a bog from which hundreds of oxen or horses could not drag it; at other times, lapping his trunk round the cannon, he will lift while the cattle and men pull forward. The native princes attach an elephant to each cannon, to aid its progress in emergencies. For this purpose the animal is furnished with a thick leather pad, covering the forehead, to prevent its being injured. It has sometimes happened that, in narrow roads or causeways, or on banks, the soil has given way under heavy cannon, when an elephant, being applied to the fallen side, has not only prevented the piece from upsetting, but even aided it forward to a state of security." Elephants have probably been employed in this manner from the first introduction of artillery into Asia. Bernier, describing the army of Aurengzebe, says, "Many of these cannon are so ponderous that twenty yoke of oxen are necessary to draw them along; and some, when the road is steep or rugged, require the aid of elephants in addition to the oxen, to push the carriage-wheels with their heads and trunks." Heavy guns are often carried on elephants' backs, both in the native and the Indian armies. ('*The Elephant*.') Elephant-riding is illustrated in Fig. 916.

Camel and Dromedary Travelling.

In the vast plains which separate India from the more western parts of Asia, the horse is perhaps more used in travelling than any other animal. At least this is so in Tartary, Bokhara, and Central Asia generally. But when we approach the sandy districts of Persia, Arabia, and Africa, we find two kinds of animals employed, especially adapted for such spots.

The *camel* and the *dromedary*, as beasts of burden, render to the inhabitants of hot sandy regions an amount of service which no other known animal could supply; and it is not therefore surprising that in all ages they should have been looked up to as invaluable. Their power of enduring fatigue, hunger, and thirst; their strength in respect to the carrying of heavy burdens; their general docility and tractableness—all concur to give them a stamp of high value.

The distinction between a camel and a dromedary is not very marked, since the latter name indicates "swiftness" rather than any peculiarity of species. There are camels with one hump, and others with two humps; and the same may be said of dromedaries; but, generally speaking, a camel has two humps, and is used to carry heavy burdens; while a dromedary has but one hump, and is employed for swift riding. The author of the 'Menageries' places in a striking light the admirable adaptation of the camel to the services for which he is employed:—"It is constituted to endure the severest hardships with little physical inconvenience. Its feet are formed to tread lightly upon a dry and shifting soil; its nostrils have the capacity of closing, so as to shut out the driving sand when the whirlwind scatters it over the desert; it is provided with a peculiar apparatus for retaining water in its stomach, so that it can march from well to well without great inconvenience, although they be several hundred miles apart. And thus, when a company of Eastern merchants cross from Aleppo to Bussorah, over a plain of sand, which offers no refreshment to the exhausted senses, the whole journey being about eight hundred miles, the camel of the heavy caravan moves cheerfully along, with a burden of six or seven hundred weight, at the rate of twenty miles a-day; while those of greater speed, that carry a man, without much other load, go forward at double that pace and daily distance. Patient under his duties, he kneels down at the command of his driver, and rises up cheerfully with his load; he requires no whip or spur during his monotonous march; but, like many other animals, he feels an evident pleasure in musical sounds, and therefore, when fatigue comes upon him, the driver sings some cheering snatch of his Arabian melodies, and the delighted creature toils forward with a brisker step till the hour of rest arrives, when he again kneels down to have his load removed for a little while; and if the stock of food be not exhausted, he is further rewarded with a few mouthfuls of the cake of barley which he carries for the sustenance of his master and himself. Under a burning sun, upon an arid soil, enduring great fatigue, sometimes entirely without food for days, and seldom completely slaking his thirst more than once during a progress of several hundred miles, the camel is patient and apparently happy."

Camels are said to be broken in to labour in the following manner. At the age of four years the trainer commences his operations on the young camel. He first doubles up one of its fore legs, which he ties fast with a cord; he then pulls the cord, and thus usually compels the animal to fall upon its bent knee. If this does not succeed, both legs are tied up, and the animal falls upon both knees, and upon the callosity, or hard protuberance of the breast. The trainer accompanies this operation with a particular cry, and with a slight blow of a whip; at this cry and blow, with the addition of a sudden jerk downwards of his halter, the camel gradually learns to lie down upon his belly, with his legs doubled under him, at the command of his driver. The trainer then accustoms him to a pack-saddle, and places on it a load, at first light, but increased by degrees as the animal increases in docility; till at last, when he readily lies down at the voice of his driver, and as readily rises up with his load, his education is so far complete. The animal is accustomed, in the same gradual manner, to allow his driver to mount, and to obey all his orders, and even his motions, in the direction of his course.

In many of the countries of Asia and Africa the camel not only supersedes the horse and the mule, but renders wheel-carriages almost unnecessary—at least in relation to the bearing of burdens. The ordinary load of a camel is five or six hundred pounds, and it is said he will frequently bear a thousand. This load may be of very varied kind; for the animal is so docile that he will carry almost anything with safety. Buckingham saw camels carrying large mill-stones six feet in diameter, each stone being perched up on the centre of the animal's hump. Sometimes the camels carry large panniers filled with heavy goods; sometimes bales are strapped on the animal's back, fastened either with cordage made of the palm-tree, or with leather thongs; and sometimes two or more will bear a sort of litter, in which women and children ride with considerable ease. Captain Lyon observed in Africa many of the children carried in leather bags, which were ordinarily used to keep corn in; and in one instance he saw a nest of children on one side of a camel, and its young one in a bag hanging on the other. In some parts of the desert the women and children place themselves in baskets made of camel's skin, and fixed in such a manner, with a wooden rim around them, over which the skin was sewed, that three or four could sit in them with perfect safety and ease, only taking care to preserve their balance.

The swift camel, or dromedary, will perform seven, eight, or ten miles an hour, for ten hours a-day, and continue this for many days together. One has been known to perform the distance of six hundred and thirty miles in five days. In the animals used for this purpose the saddle is placed on the withers, and confined by a band under the belly; it is very small, and difficult to sit, which is done by balancing with the feet against the neck of the animal, and holding a tight rein to steady the hand. Europeans find some difficulty in learning to seat themselves carefully on camels. The rider gets on while the animal is crouching down; and the camel rises by several oscillatory movements, first elevating his hind-legs a little, then his fore-legs, then his hind-legs again, and so on, by which the inexperienced rider is in imminent danger of being pitched over the head of the animal. Riley, an Englishman, who was wrecked on the African coast, and made captive by the roaming tribes of the interior, thus describes one of his adventures in camel-riding:—"They placed me on the largest camel I had yet seen, which was nine or ten feet in height. The camels were now all kneeling or lying down, and mine among the rest. I thought I had taken a good hold to steady myself while he was rising; yet his motion was so heavy, and my strength so far exhausted, that I could not possibly hold on, and tumbled off over his tail, turning entirely over. I came down upon my feet, which prevented my receiving any material injury, though the shock to my frame was very severe. The owner of the camel helped me up, and asked me if I was injured? I told him, No. 'God be praised!' said he, 'for turning you over: had you fallen upon your head, these stones must have dashed out your brains. But the camel,' added he, 'is a sacred animal, and heaven protects those who ride on him. Had you fallen from an ass, though he is only two cubits and a half high, it would have killed you; for the ass is not so noble a creature as the camel and the horse.' I afterwards found this to be the prevailing opinion among all classes of the Moors and the Arabs. When they put me on again, two of the men steadied me by the legs, until the camel was fairly up, and then told me to be careful, and to hold on fast."

The saddled dromedaries could always travel much more rapidly than the baggage-camels in the caravans which traverse the desert; but all must keep together, for mutual protection. It is usual, however, for horsemen, and those who become wearied with the monotonous slowness of the caravan, to gallop on to the head of the caravan, dismount, allow their animals and themselves to repose a little, and wait till the whole assemblage has passed them; after which they are easily enabled to regain their former position.

The modes of saddling and riding these animals are illustrated in Figs. 896, 919, 924. With respect to the second of these, Fig. 919, it exhibits one of the *Caravanserais*, or resting-places, for Eastern travellers. In countries where inns or houses of entertainment are almost unknown, and where large parties travel together, the establishment of roomy and well-known stations is most important. At these caravanserais the camels are unladen and allowed to refresh themselves in the best way circumstances admit; the horses are in like manner left at liberty for a time; and the way-worn riders halt to refresh themselves before resuming their march, perhaps after several hundred miles of parching desert. These caravanserais are established near wells, whence cool and drinkable water may be obtained.

Sledge-travelling, in the Northern parts of America.

The existence on the ground of a layer of snow gives rise to a mode of travelling peculiar to itself—viz. that by means of the *sledge*, drawn by dogs, horses, or rein-deer.

The employment of the *dog* for purposes of travelling is more observable among the Esquimaux than among any other people: indeed this people are dependent on the aid of the dog for most of the few comforts of their lives. It has been said that "in the summer a single dog carries a weight of thirty pounds in attending his

master in pursuit of the game: in winter, yoked in numbers to heavy sledges, they drag five or six persons at the rate of seven or eight miles an hour, and will perform journeys of sixty miles a-day. What the rein-deer is to the Laplander the dog is to the Esquimaux. He is a faithful slave, who grumbles, but does not rebel; whose endurance never tires; and whose fidelity is never shaken by blows and starving. These animals are obstinate in their nature; but the women, who treat them with more kindness than the men, and who nurse them in their helpless state, or when they are sick, have an unbounded command over their affections." (*Menageries*, vol. i.)

Sir Edward Parry has described very minutely the mode of employing the Esquimaux dogs in drawing sledges. When so engaged the dogs have a simple harness of deer or seal-skin, going round the neck by one bight, and another for each of the fore-legs, with a single thong leading over the back, and attached to the sledge as a trace. Though they appear at first sight to be huddled together without regard to regularity, there is, in fact, considerable attention paid to their arrangement, particularly in the selection of a dog of peculiar spirit and sagacity, who is allowed, by a longer trace, to precede the rest as leader, and to whom, in turning to the right or left, the driver usually addresses himself. This choice is made without regard to age or sex; and the rest of the dogs take precedence according to their training or sagacity, the least effective being put nearest to the sledge. The leader is usually from eighteen to twenty feet from the forepart of the sledge, and the hindmost dog about half that distance; so that when ten or twelve are running together, several are nearly abreast of each other. The driver sits quite low on the fore part of the sledge, with his feet overhanging the snow on one side, and having in his hand a whip, of which the handle, made of wood or bone, or whalebone, is eighteen inches, and the lash more than as many feet, in length; the part of the thong next the handle is platted a little way down to stiffen it and give it a spring, on which much of its use depends; while that which composes the lash is chewed by the women to make it flexible in frosty weather. The men acquire from their youth considerable expertness in the use of this whip, the lash of which is left to trail along the ground by the side of the sledge, and with which they can inflict a very severe blow on any dog at pleasure. Though the dogs are kept in training entirely by fear of the whip, and indeed would without it soon have their own way, its immediate effect is always detrimental to the draught of the sledge; for not only does the individual that is struck draw back and slacken his trace, but generally turns upon his next neighbour; and this interruption, passing on to the next, occasions a general diverging, accompanied by the usual yelping and showing of the teeth. The dogs then come together again by degrees, and the draught of the sledge is accelerated; but even at the best of times, by this rude mode of draught, the traces of one-third of the dogs form an angle of thirty or forty degrees on each side of the direction in which the sledge is advancing. Another great inconvenience attending the Esquimaux method of putting the dogs to, besides that of not employing their strength to the best advantage, is the constant entanglement of the traces by the dogs repeatedly doubling under from side to side to avoid the whip; so that, after running a few miles, the traces always require to be taken off and cleaned.

In directing the dog-sledge, the whip acts no very essential part, the driver for this purpose using certain words, as the carters do with us, to make the dogs turn more to the right or left. To these a good leader attends with admirable precision, especially if his own name be repeated at the same time, looking behind over his shoulder with great earnestness, as if listening to the directions of the driver. On a beaten track, or even where a single foot or sledge-mark is occasionally discernible, there is not the slightest trouble in guiding the dogs: for even in the darkest night, and the heaviest snow-drift, there is little or no danger of their losing the road, the leader keeping his nose near the ground, and directing the rest with wonderful sagacity. Where, however, there is no beaten track, the best driver among them makes a terribly circuitous course, as all the Esquimaux roads plainly show. On rough ground, as among hummocks of ice, the sledge would be frequently overturned, or altogether stopped, if the driver did not repeatedly get off, and by lifting or drawing it to one side, steer clear of those accidents. At all times, indeed, except on a smooth and well-made road, he is pretty constantly employed thus with his feet, which, together with his never-ceasing vociferations, and frequent use of the whip, renders the driving of one of these vehicles by no means a pleasant or easy task. When the driver wishes to stop the sledge he calls out "Wo, woa!" exactly as our carters do; but the attention paid to this command depends altogether on his ability to enforce it. If the weight is small, and the journey homeward, the dogs are not to be thus delayed; the driver is therefore obliged to dig his heels into the snow to obstruct their progress, and, having thus succeeded in stopping them, he stands up with one leg before the foremost cross-piece of the sledge, till, by laying the whip gently over each dog's head, he has made them all lie down. He then takes care not to quit his position, so that, should the dogs set off, he is thrown upon the sledge instead of being left behind by them.

The rate at which the dogs travel depends on the weight to be drawn, and on the state of the snowy surface. When the road is hard and smooth, six or seven dogs will carry from eight to ten hundred weight, at the rate of seven or eight miles an hour, for several hours together; and will easily, under these circumstances, perform a journey of fifty or sixty miles a-day. On untrodden snow, five-and-twenty or thirty miles would be a good day's journey. In Fig. 900 we have given a sketch of a party of Laplanders drawn by a troop of dogs. The scene depicted in Fig. 894 is one with which most persons are familiar in London; but by a recent enactment such an employment of dogs is rendered illegal, for it was usually accompanied by great cruelty, besides being unfitted for the structure and habits of English dogs.

There is, in a more southern part of the American continent, viz. Canada, a mode of sledge-riding called *sleighing*, in use at particular seasons of the year. The authoress of the 'Backwoods of Canada' says:—"In the towns and populous parts of the province the approach of winter is hailed with delight instead of dread; it is to all a season of leisure and enjoyment. Travelling is there expeditiously and pleasantly performed. Even our vile bush-roads become positively very respectable; and if you should happen to be overturned once or twice during a journey of pleasure, very little danger attends such an event, and very little compassion is bestowed on you for your tumble in the snow; so it is wisest to shake off your light burden and enjoy the fun with a good grace, if you can. Sleighing is certainly a very agreeable mode of travelling; the more snow, the better is the sleighing season considered; and the harder it becomes, the easier the motion of the vehicle. The horses are all adorned with strings of little brass bells about their necks or middles: the merry jingle of these bells is far from disagreeable, producing a light, lively sound. As soon as a sufficient quantity of snow has fallen, all vehicles of every description, from the stage-coach to the wheelbarrow, are supplied with wooden runners, shod with iron after the manner of skates. The usual equipages for travelling are the double sleigh, light waggon, and cutter; the two former are drawn by two horses abreast; but the latter, which is by far the most elegant-looking, has but one, and answers more to our gig or chaise."

In the general arrangement of these Canadian "sleighs" the runners upon which the body of the vehicle rests are about eighteen or twenty inches high; and where they stand upon the ground, about two feet nine inches asunder. They are not placed quite perpendicularly, but sloping outwards, so that the upper part of the frame upon which the body of the sleigh rests is a few inches narrower than the space upon which the runners stand. This position of the runners prevents the sleigh from being easily upset; and in order the more to guard against its overturning, it is provided with horizontal side-pieces or "fenders," projecting eight or nine inches along the whole upper line of the frame, so that should the sleigh by any accident be overturned, the fender would prevent it from falling flat upon its side, and consequently the sleigh-riders would probably not be thrown out. Sometimes, in snowy weather, the inhabitants of a village will join in a "sleighing-frolic,"—that is, a number of sleighs are fitted out, to hold two persons each; and the whole set off in a party, to spend the day at some place ten or twenty miles from home; every horse being decked with jingling bells. One form of the sleigh is shown in Fig. 915.

Sledge-travelling, in the Northern Parts of Europe.

The reindeer sledges of Lapland are, however, those which have the most frequently been made subjects for description, owing principally to the invaluable services rendered by the animals which draw them. The Laplanders are divided into two great parties; viz., those who live near shore, and subsist by fishing, and those who wander through the country, with no home but their temporary tents. It is to these latter that the reindeer are so invaluable. Sir Arthur De Capel Brooke, in his account of Lapland and the Laplanders, states that the number of reindeer belonging to a herd is from three hundred to five hundred; with which number a Laplander can do well and live in tolerable comfort. He can make in summer a sufficient quantity of cheese for the year's consumption; and, during the winter season, can afford to kill deer enough to supply himself and his family pretty constantly with venison. With two hundred deer, a man, if his family be but small, can manage to get on. If he have but one hundred, his subsistence is very precarious, and he cannot rely entirely upon them for support. Should he have but fifty, he is no longer independent or able to keep a separate establishment, but generally joins his small herd with that of some richer Laplander, being then considered more in the light of a menial, undertaking the laborious office of attending upon and watching the herd, bringing them home to be milked, and other similar offices, in return for his subsistence.

The above remarks apply to the reindeer as a source of sustenance; but it is as affording the means of travelling that we have here to do with this animal. When the winter has fairly set in, travelling would be impracticable in Lapland without the reindeer. When harnessed to a sledge, these animals, with a load of from two to three hundred pounds behind them, will trot at the rate of ten miles an hour for nearly an entire day. On one occasion, at the latter end of the seventeenth century, a reindeer is said to have accomplished the marvellous distance of eight hundred miles in forty-eight hours; he was driven by an officer who was bearing important despatches; and the poor animal dropped down dead at the conclusion of the task.

When a number of Laplanders are travelling together in their sledges, the reindeer instinctively range themselves in a line one behind another; and so strongly impelled do the animals seem to follow this course, that the travellers are obliged to submit to it. If the guide or leading reindeer alter his direction, by making a bend to the right or left, the whole of his followers do the same; and though the traveller in the hindmost sledge might make a considerable saving of distance by striking across the chord of the curve instead of making the detour, yet it is scarcely possible to do so; for should the deer even be pulled by main force out of its former course, it will immediately turn aside from the new direction it is placed in and regain the old track. This instinct seems to be given to the animal for the sake of mutual protection; and the Laplanders, though sometimes delayed in their course by it, owe much of their safety to its exercise. If, during the passage of a party across the snows, one gets separated from the rest, the rider leaves the matter entirely to the sagacity of the reindeer; the animal gallops on rapidly, keeping his nose close to the ground, and smelling the track of those which have preceded him, by which means he is sure to overtake them after a greater or less period.

The author mentioned above gives two examples, to show the difference between reindeer-travelling when the animals are well or ill trained to their work:—"We again resumed our course, the deer appearing no way fatigued, and proceeding so steadily and quietly that the act of driving them was merely holding the rein, which became at last so tedious that some of the party behind lashed their deer to the sledge before, the whole keeping up a long steady trot. This is the usual travelling pace of the reindeer while performing long journeys; for though, occasionally, the animal may proceed at a gallop for some miles on first starting, or in those situations where the snow is very good, it is natural to suppose it will gradually relax its pace. The speed of the party, however, is entirely dependent upon the foremost deer, by which the motions of those behind are almost entirely regulated; and I observed that, when we first set off in the morning, the instant it had its head at liberty, it almost invariably commenced a full gallop, the rest following at a similar pace, as if moved by one common impulse. This was kept up by them as long as they remained unexhausted, the driver having little power to stop the animal, from the rein being merely attached in the manner it is to the head. . . . . The deer we had procured were as unmanageable and unruly as deer could well be, being none of them well broken in; and our first set off was by no means a pleasant one, as, after tumbling with the swiftness of lightning down the steep bank of the river, the deer proceeded at full gallop across a very rough and broken country, with steep and slippery descents. It was quite impossible, from the nature of the ground, to prevent being frequently rolled over in the pulk (sledge); and, when this was the case, the strength and freshness of the deer, and the good order of the snow, which was very hard, made them regard very little the additional weight caused by the prostrate position of the sledge; so that they continued to follow, at full speed, the rest of the deer, leaving the unfortunate wight at their heels to find his balance again as well as he could (the traveller is strapped down to the sledge). Notwithstanding that which had been harnessed to my pulk was by no means a lamb in quietness, I had good reason to congratulate myself upon having escaped the animal which one of the party had to his share, and which was a deer of the wild breed that had been caught when young by the Laplanders; in size it was larger than the others, thinner, with more appearance of bone, and considerably stronger. With respect to any command over it, this was quite out of the question; and it dragged pulk and driver along with the greatest ease wherever it pleased." Reindeer sledges are sketched in Figs. 899, 923.

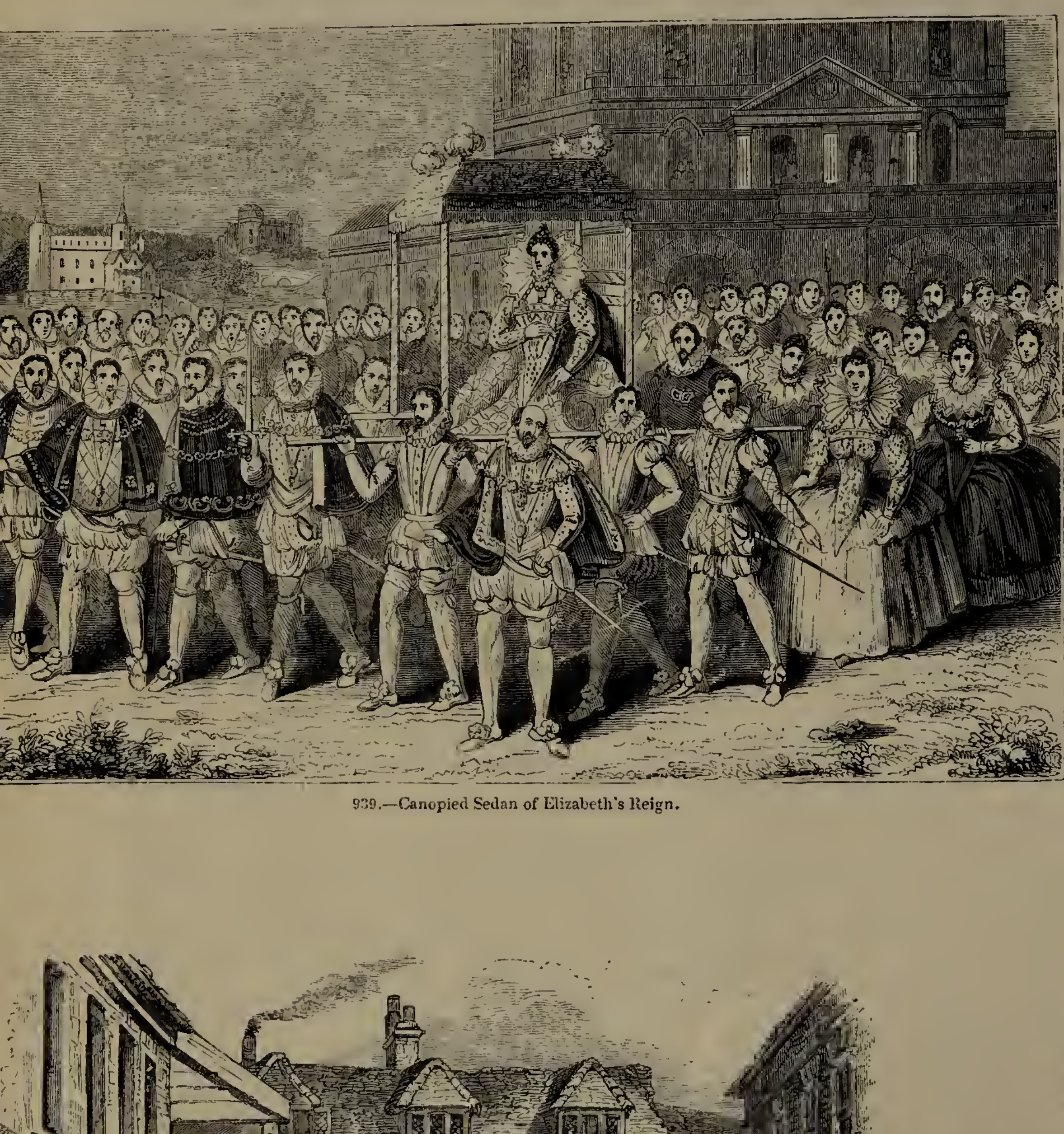
Ox-travelling.

The use of the ox as a beast of draught, and even saddled, has been described by many travellers in different parts of the world. Thus Thevenot, while speaking of the Brahmin bulls and other animals of India, says,—"As the oxen in India are by no means ungovernable, there are many persons who employ them in travelling, and who mount them as they do

937.—Hackney-Coaches, time of Charles I.

938.—Sedan Chairs. (From Old English Prints.)

940.—Sedan, time of Charles I.



939.—Canopied Sedan of Elizabeth's Reign.

941.—Hackney-Coachman, time of Charles I.

942.—Country Waggons in an Inn Yard.

943.—Coaches and Horse-Sedans of the Sixteenth Century.

944.—Carriages, time of King John. (Taken from Ancient MSS.)

945.—Coaches of the time of Charles II.

948.—Hackney-Cab fifty years ago.

947.—Coaches and Sedans: a century ago.

950.—"Tiring" a Wheel.

949.—Coaches of the time of Queen Anne.

951.—Bow-spring of a Carriage.

horses. Their ordinary gait is easy; instead of a bit, a small cord is passed double through the gristle of the nose, and to this is attached a stout cord, in the fashion of a bridle, which is kept up by the hump which the animal has on the fore part of the back, and which is wanting in our oxen. The animal is saddled like a horse, and when a little excited into action it goes very quickly; some, indeed, gallop as well as a good horse. These cattle are in general use throughout the whole of India; and they use no other in ploughs, coaches, and chariots, which are drawn by oxen, their number being in proportion to the weight of the load. They are harnessed by means of a long yoke at the end of the pole, which is placed on the neck of the two oxen, and the driver holds in his hand the cord to which is attached the small double cord passed through the nostrils."

Another traveller, Tavernier, says,—"The two oxen which were harnessed to my carriage cost me nearly six hundred rupees. The reader need not be astonished at this price; for these are oxen of great strength, and which travel journeys of twelve to fifteen leagues a day for sixty days, and always on the trot. When they have done half their day's work they have two or three balls (the size of a penny-loaf) of wheaten flour kneaded with butter and coarse sugar; and in the evening their ordinary fare consists of chick-peas, bruised and steeped half an hour in water." Bishop Heber, too, remarks that many of the Hindoo nobility are accustomed to travel in covered waggons drawn by oxen; the horns of the oxen being gilt, as a mark of distinction.

Chardin states that the oxen of Persia are reared chiefly as beasts of burden; the hoofs of the animals being shod with iron, in consequence of the stony mountains over which they often have to travel. The shoes are light, and two are placed on each foot, in consequence of the cloven form of the hoof.

But, of all other nations, the Hottentots have derived the greatest amount of advantage from the use of the ox as a beast of burden. It has been observed, that what the horse is to the Arab—his companion and assistant—that was the ox to the Hottentot, before the Hottentot was deprived of his independence, and whilst he could call his country his own. Under his culture the ox displayed a degree of intelligence superior to that of any animal, the dog excepted, and scarcely to be surpassed by him. The sharer of his master's toils and wars, his companion at all times, and his assistant in the fields as the guardian and defender of the flock, the ox seemed to lose its ordinary character and rise into a higher sphere of being.

All the travellers in central and southern Africa take occasion to allude to the use of this animal. Kolben speaks of certain selected oxen, called *backeleys*, which are employed in war to rush upon the enemy, trampling, striking, goring, and kicking with the greatest fury, and yet being perfectly manageable by their owners. The backeleys act also as guardians of the other oxen, attacking with the utmost fury any Boschmen or robbers who may approach a kraal or village. Le Vaillant says that these backeleys form one of three classes into which oxen are divided by the Hottentots; the other two being saddle-oxen and draught-oxen.

According to Burchell's account, the saddle-oxen are generally broken in for riding when they are not more than a year old. The first ceremony is that of piercing the nose to receive the bridle; for which purpose the ox is thrown on his back, and a slit is made through the septum, or cartilage between the nostrils, large enough to admit a finger. In this hole is thrust a strong stick, stripped of its bark, and having at one end a forked branch to prevent it passing through. To each end of it is fastened a thong of hide, of sufficient length to reach round the neck and form the reins; and a sheep's skin, with the wool on, placed across the back, together with another folded up, and bound on with a rein long enough to pass several times round the body, constitutes the saddle. To this is sometimes added a pair of stirrups, consisting only of a thong with a loop at each end, slung across the saddle. Frequently the loops are distended by a piece of wood, to form an easier rest for the foot. While the animal's nose is still sore, he is mounted and put in training, and in a week or two is generally rendered sufficiently obedient to its rider. The facility and adroitness with which the Hottentots manage the ox are quite remarkable: the animal is made to walk, trot, or gallop, at the will of its master; and, being longer legged and rather more lightly made than the English ox, he travels with greater ease and expedition, walking three or four miles in a hour, trotting five, and galloping on an emergency seven or eight.

It is, however, rather for draught than for the saddle that the ox is useful in Africa—at least to the Boors, or Dutch settlers, by whom ox-waggons are extensively used. In earlier times the waggons were extremely large, clumsy, and heavy; and indeed they are still very little otherwise. Latrobe says,—"The waggons in use at the Cape are still very heavy. The oxen draw by a wooden yoke, consisting of a strong bar laid across their necks, to which are fixed in right angles downwards four short pieces, so as to admit the neck of each animal between two of them. These are kept in their places by being tied together below the neck with a small thong. A strongly plaited leather thong runs from the ring at the end of the pole to the yoke of the first pair of oxen; being fastened, in passing, to the middle rings of each yoke. The bullocks, by pushing, seem to draw with ease. The Hottentot driver has a whip, the stick of which is a strong bamboo, twelve or more feet long, and the lash a plaited thong of equal or greater length. With this, to European grasp, unwieldy instrument he not only cracks very loud, but hits any one of the bullocks with the greatest surety. But the chief engine of his government is his tongue; and he continually calls to his cattle by their names, directing them to the right or left by the addition of the exclamations of '*pott*' and '*haar*,' occasionally enforcing obedience to his commands by a lash, or by whisking or cracking his whip over their heads. A boy leads the foremost oxen by a thong fastened about their horns, and they seem to follow him willingly."

It will suffice to give one more example of this mode of travelling, from an account of an emigrant party at Algoa Bay:—"Our travelling train consisted of seven waggons, hired from Dutch-African colonists, and driven by the owners, or their native servants, slaves, and Hottentots. These vehicles appeared to be admirably adapted for the country, which is rugged and mountainous, and generally destitute of any other roads than the rude tracks originally struck across the wilderness by the first European adventurers. Each waggon was provided with a raised canvas-tilt, to protect the traveller from sun and rain, and was drawn by a team of ten or twelve oxen, fastened with wooden yokes to a strong central trace or *trekton* formed of twisted thongs of bullock or buffalo hide. The driver sat in front to guide and stimulate the oxen, armed with a whip of enormous length; while a Hottentot or Bushman boy, running before, led the team by a thong attached to the horns of the foremost pair of bullocks. Where the road was bad and crooked, or when we travelled at a rapid rate, as we frequently did on more favourable ground, these leaders had a very toilsome task; and, if they made any mistake, or in aught displeased the lordly *boor* (gruff boor who sat behind), his formidable lash was not unfrequently applied to their naked limbs." Various examples of the employment of the ox in travelling are given in Figs. 898, 904, 906, 914, 920, 928. Of the first of these, the "Bullock-caravans of Moldavia," we shall say a few words farther on.

Ass-travelling in Egypt.

With respect to the *ass*, as used with the saddle, Mr. Lane says that they, as well as horses and mules, are employed by the Egyptians. Asses are most generally used for riding through the narrow and crowded streets of Cairo; and there are many for hire: their usual pace is an easy amble. The ass is furnished with a stuffed saddle, the fore part of which is covered with red leather, and the seat with a kind of soft woollen lace of red or yellow colour. The stirrup-leathers are very short. The horseman is preceded by a servant, or by two servants, to clear the way; and, for the same purpose, a servant generally runs beside or behind the ass, or sometimes before, calling out to the passengers to move out of the way to the right or left, or to take care of their backs, faces, sides, feet, or heels. The rider, however, has need of all his vigilance, in addition to the services of an attendant; for he is sometimes liable to be overthrown by a laden camel in the narrow streets of Cairo.

Mrs. Poole, the sister of Mr. Lane, in her interesting volumes, entitled the 'Englishwoman in Egypt,' while describing a visit which she paid in Cairo, says:—"I felt more than ever convinced that donkeys were the only safe means of conveyance in the streets of this city. A lady never rides but on a donkey, with a small carpet laid over the saddle. For gentlemen, horses are now more used than donkeys; but their riders encounter much inconvenience. In many cases, this morning, our donkeys threaded their way among loaded camels, where horses were turned back; and my apprehensions lest the large bales of goods should really sweep my boys from their saddles, were scarcely removed by the extreme care of their attendants, who always kept one arm round each of my children in passing through the dangerous thoroughfares. I assure you it is an exceedingly awkward thing to ride through the streets of Cairo at any time, but especially so during a season of festivity." The riding-ass of Egypt is saddled in the way shown in Fig. 925; except a mode called the "high-ass," which Mrs. Poole describes as being more convenient for ladies, though requiring more care in riding.

Sedan-travelling in the East.

There is a very frequent mode of travelling observable in Oriental countries, in which, though a carriage is employed, no other bearers than men are necessary. In most cases these arrangements are made where, while on the one hand the wealthy and the noble disdain to walk on foot, the roads are too imperfect for wheel-carriages to pass in safety. In such instances a sedan or palanquin, borne on the shoulders of men, becomes a convenient mode of travelling.

In India, in the absence of good roads and efficient travelling arrangements, a very peculiar system, called the *dawk* or *dâk*, is adopted. This is a kind of post-system for the conveyance of letters, and also a quick mode of travelling for individuals. There are persons employed as "dawk-runners," to convey the letters and to bear the palanquins in which the travellers sit. When the runners are engaged in the conveyance of an express, they travel at the rate of five miles an hour; but with a large burden of newspapers and letters they attain four miles. The road is divided into stages varying from five to ten miles each, and the runners act on a continued system of operations in the following manner:—The journey is divided into stages, and there are two runners to each stage; one runner starts from one end of the stage, while the other starts from the other, going in opposite directions, and each one carrying a "bangy," or box, containing the mail; on the following day each runner retraces his steps, so that they proceed to and fro alternately. Besides this system between the two runners of each stage, there is an interchange of mails between the runners of two adjoining stages. When one runner has arrived at the end of his stage, he meets another who has just come in an opposite direction along the adjoining stage; the two men exchange mail-boxes, and each one retraces his steps. There are stations or meeting-places where these interchanges take place.

The dawk-runners are divided into two classes: the "bangy-burdars," of whom we have just spoken; and the "palanquin-burdars," who carry travellers. The palanquins employed for this latter purpose are a kind of sedan, with the poles resting on the shoulders of the bearers. The men and palanquins are supplied by a kind of postmaster in the employ of the government, and the fare is paid in advance. There are "bungalows," or stations, at distances of ten or fifteen miles apart, in which a rude sort of inn-accommodation is obtainable. Bishop Heber describes a dawk-journey which he made; and from this description we learn that only four persons can put their shoulder to the palanquin at once, but that many others are provided to alternate with these four, and to assist in passing difficult and dangerous parts of the country. The clothes and writing-desk of the traveller were placed in two wicker-boxes, which one man carried slung on a bamboo across his shoulders. Heber says:—"Such is the usual style in which dawk-journeys are made in India; and it may serve as an additional proof of the redundant population and cheapness of labour, that this number of bearers are obtained, for this severe and unpleasant work, at about twelve shillings for the stage, varying from six to ten miles. The men set out across the meadows at a good round trot of about four miles an hour, grunting all the while like paviors in England, a custom which, like paviors, they imagine eases them under their burden."

This kind of palanquin-travelling is (as we have observed) not by any means uncommon in the East. It is a prevalent mode in China, where, out in the streets, a mandarin of high rank would, Mr. Davis informs us, "be considered degraded except in a chair with four bearers." In Japan, too—little as we know about the country in any sense—there is abundant proof of the palanquin-system being a favourite one. Captain Saris, an old writer who visited Japan two centuries ago, thus speaks of the travelling arrangements which he met with:—"I had a palanquin, or one of their sedans, provided for me; and a fresh supply of men drawn out of every place successively, for the office of carrying me therein when I was tired of my horse; and for the greater state a slave appointed to run with a pike before the palanquin. The king's harbingers also went before, and took up our lodgings on the road. This part of the journey was very pleasant and easy; the way for the most part was exceeding even and plain; and wherever there was any rugged mountainous ground, a smooth level passage was cut through it. This road (one of the great roads through the island of Niphon) is all along good gravel and sand; it is divided into leagues for the benefit of travellers; and at every league of road are two small hills raised of either side one, and upon each of them a fair tree planted; the design of which marks is to make travellers competent judges of the length of their own journeys, that so they may not be abused by the hackneymen and those that let out horses, and pay for a greater number of miles than they have ridden."

In Fig. 897, taken from an ancient Egyptian painting, we have evidence of the use of palanquins in early times; in Figs. 903, 908, are two palanquins such as are now used in the East; and in Fig. 911 are shown some of the Japanese palanquins.

VEHICLES AND TRAVELLING ARRANGEMENTS OF MODERN EUROPE.

Mr. Adams, in his 'Treatise on Pleasure-Carriages,' traces the steps by which a rude country would probably arrive at the use of vehicles for land-

travelling. The first and most simple form of it would naturally be a land-raft or sledge, which, if not heavily loaded, would move in favourable localities with considerable facility, as over dried grass, or green turf, or ice, or on the surface of hardened snow. In the northern countries both of Europe and America the sledge is constantly used upon the snow at the present day; for which purpose it is better adapted than wheel vehicles, the great length of the two bearers preventing them from sinking in the snow as wheels would do. In the island of Madeira the heavy pipes of wine are drawn on sledges from the mountain-vineyards to the sea-ports; and part of the driver's business is to walk by the side of them with a kind of mop, to keep the surface of the bare rock on which they run constantly wetted, to diminish the friction. Another instance is the sledge used by the London brewers, and drawn by a single horse, to convey barrels of light weight. But it is evident that, except under peculiar circumstances, the friction of sledges is so great as to cause a great loss of animal power; and, therefore, better vehicles must have been objects of desire at a very early period. In mountainous countries sledges could scarcely be used except down hills, and accordingly in mountainous countries the next stage of improvement must have been first adopted.

The next stage was, probably, the elevation of the sledge from the ground, and its suspension from the backs of two or four oxen or horses, by means of pack-saddles and lashings. Such an arrangement, under the name of a *litter*, has been adopted in many countries, and differs from the sedan or the palanquin chiefly in being borne by mules, horses, or oxen, instead of by men. But, in all arrangements of this kind, the whole weight of the vehicle has to be borne, in addition to the drawing or pulling. To remedy this wheels were introduced, by the action of which the weight is borne chiefly by the ground, while the onward movement is not much affected by friction. Following out the mode of improvement sketched by Mr. Adams, the next step would be to place a frame on the rounded axle of the wheels, capable of bearing burdens; the axle being confined to perform its revolutions at or near the centre of gravity of the frame by thole-pins or guides similar to the row-locks of a boat. The form of the frame would be a central pile or beam, sufficiently long to bear the bulk or volume of the load, and also to project forward between the two draught-horses or oxen. Parallel with the central beam would be ranged two side-bearers, and these would be connected together by cross-framings or diagonal bearings. This would then be a car or cart, the simplest possible form of wheel-carriage. As a further step, means would be adopted for enabling the cart to turn in a circle or curve, without such an immense loss of power by friction as would otherwise occur. To effect this, each wheel would be made to revolve on its own centre; instead of fixing the cross-beam or axle in a square hole, it would be made to play easily in a round one of a conical form. After all, a machine made in this manner would not be well adapted for rapid motion, without a great expenditure of power; the axle, being of wood, must necessarily be of considerable size; and working in wood also, a rapid motion would cause so much friction that it would soon be cut through, even though the hardest wood might be sought. The wheels, too, being heavy and solid, would add much to the weight; and the invention of spoked wheels would be a notable step in advance.

Carts and Cars of various Countries.

Though we may not be able to show that the above was the exact order in which successive improvements were made, there is abundant evidence of the existence and use of carts and cars in almost every grade of rudeness. In some mountainous districts there is a "drag-cart" employed of the following kind:—It consists of two strong poles, from twelve to fifteen feet long, connected by cross-pieces fixed at right angles to them by mortising or pinning, so that the poles may be two or three feet apart; about eighteen inches of the poles project beyond the lowest cross-piece, the ends resting on the ground; and the other ends of the poles form the shafts for the horse. The load is placed on the cross-pieces, over which boards are sometimes nailed, for the purpose of carrying stones or such things as might fall through between the cross-bars; it then resembles the body of a cart taken off the wheels. The horse bears one end of the drag-cart by a strap over his back, and drags it on by means of a common cart-collar or a breast-strap.

The Irish car, in its rudest form (shown in the middle portion of Fig. 922), consists of a bed or platform, and two shafts. The wheels are round disks of wood made by nailing planks two or three inches thick over each other, so that the fibres of the wood in one plank shall be at right angles to those in the other; they are then sawn into the form of a circle and an iron tire put on the circumference. Two of these disks or wheels are fixed on a square axle of wood at the distance of three or four feet from each other. The ends of the axle, which project three or four inches beyond the wheels, are then rounded in the form of cylinders of two or three inches diameter. To the under part of the bed of the car two blocks of wood are fixed, which raise it so that the wheels may go under the car, and in these blocks are two round holes to admit the ends of the axle. Two strong nails or iron pins driven obliquely into the box, after the wheels are put under, serve to prevent the axle from slipping out. All the Irish cars are constructed nearly on this principle; viz. the revolving of the axle with the wheels, and the resting of the body itself on the axle. In the pleasure-cars the wheels, the body, and indeed all the various parts, are neater and better made.

In France and Germany carts are employed such as are shown in the upper and lower parts of Fig. 922. This simple vehicle consists of two strong poles of ash or beech, made very strong at the place where they rest on the axle-tree; one end forms the shafts, and the whole is equally poised on the axle. The wheels are often nearly six feet in diameter, and narrow at the tire; they are slightly dished, but run nearly perpendicularly to the road. On these carts very great weights are transported, so as to require five or six horses to draw them.

In the *ox-carriage* of India before referred to (Fig. 904), though there is some attempt at smartness about it, the vehicle itself is evidently constructed in a very rude manner. The car of Portugal and the ox-cart of the Pampas (Figs. 905, 907) exhibit two specimens extremely simple in their structure. The latter, which are employed to convey provisions and water across the pampas or plains of South America, are about seven feet high. On the frame of the cart a wattling of sticks is erected, arched at the top, the sides being thatched with rushes, and the roof covered with untanned hides; no metal whatever is used in the construction.

The carts employed at the present day in Wales (Fig. 921) to bring agricultural produce to market, are singular specimens of construction. King, in the 'Munimenta Antiqua,' after comparing some of these carts to the ancient war-chariots, says:—"It is surely a striking fact that the present modern Welsh are no less remarkable for using a vast, unnecessary, and quite disproportionate number of carts or cars, on many occasions, than their ancestors were. I myself have seen, near Penrice, in Glamorganshire, a farmer carrying home a part of his harvest by means of a procession of twelve little carts, each drawn by one horse, with a man or woman riding upon it, and followed by a train of twelve single horses, each having a man or woman riding in like manner, and carrying behind them merely two or three sheaves of corn tied up in bags; while the whole convoy, though consisting of twenty-four riders and horses and twelve carts, did not carry home more corn than would have been a load for an English waggon, nor perhaps so much."

With respect to the war-chariots of old times, alluded to above, it is pretty evident, from an inspection of Figs. 906, 910, 912, 917, 918, 920, 931, that however different one from another may be the vehicles there sketched, and however diverse the sources whence they were derived, they partake much more of the simplicity of the car or cart than of the complexity of the coach.

The beach-carts of Yarmouth, by which fish is brought from the vessels to the town (Fig. 934), are another example of simply-constructed vehicles.

Travelling in the East of Europe.

When we come to view the general arrangements connected with the vehicles and the travelling in any country, we find the relative scantiness of the population to have a good deal to do with the matter. In Russia, for example, where desolate plains or "steppes" spread far and wide, and where the climate is generally very rigorous, the accommodations for travelling are of a comfortless kind. The *telega* (Fig. 932) is a rude but rapid vehicle used in the northern parts of the empire. It is a kind of cart, with litter spread for the accommodation of the traveller; in front, with no other seat than a narrow board, sits the driver, who talks to the horses without ceasing; and in front of the pole is suspended an iron bell, which serves to announce their arrival at a post-station. In such a rude vehicle as this, travellers, officers, agents, carriers, and government functionaries, are continually traversing the empire in every direction—often galloping night and day, with scarcely any stoppage for days together.

Another Russian vehicle is the *droschky*, in which the traveller rides astride on a cushioned seat which extends from front to back of the vehicle. These vehicles may be seen clustered together in the streets of St. Petersburgh for hire, or standing in a row close to the footway before moveable mangers of wood filled with hay. The driver, or *isvostchik*, habited in a picturesque costume, is recognised by a square tin plate hanging between his shoulders, on which is engraved the number of his vehicle.

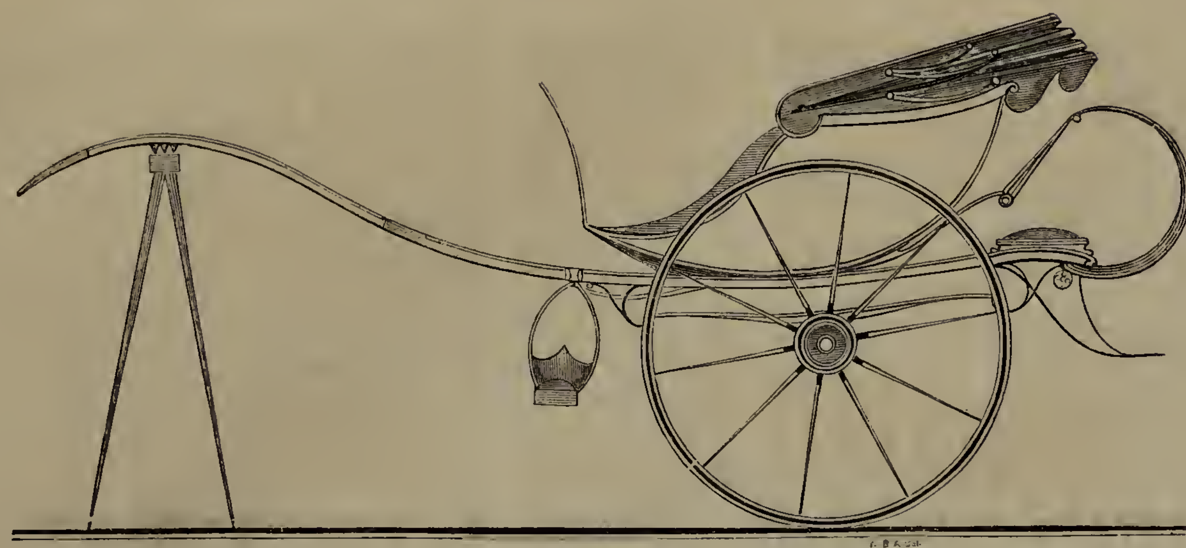
The travelling in Turkey partakes of many of the peculiarities which distinguish that country in other matters. Vehicles are very few in number in Turkey, on account partly of the badness of the roads. In the northern parts of the empire, such as Moldavia, where the inhabitants are rather Sclavonic that Turkish in their character, goods are very frequently transported by means of bullock-caravans, such as that sketched in Fig. 898; but in the more southern provinces Oriental customs rather prevail. The Moldavians are said to be very partial to this mode of roaming over the country. They join to form large caravans or companies, and roam over a very large tract of country; transporting, in their curious basket-like vehicles, provisions and commodities of various kinds. So dreary and desolate is the country, that they sometimes travel a month without seeing a single habitation. They travel slowly, and, at the end of each day's journey they arrange the waggons in the form of a square, and allow the oxen to graze at pleasure, under the vigilant care of a troop of watch-dogs. The wayfarers light a a fire in the middle of the square formed by the waggons, and there eat and sleep.

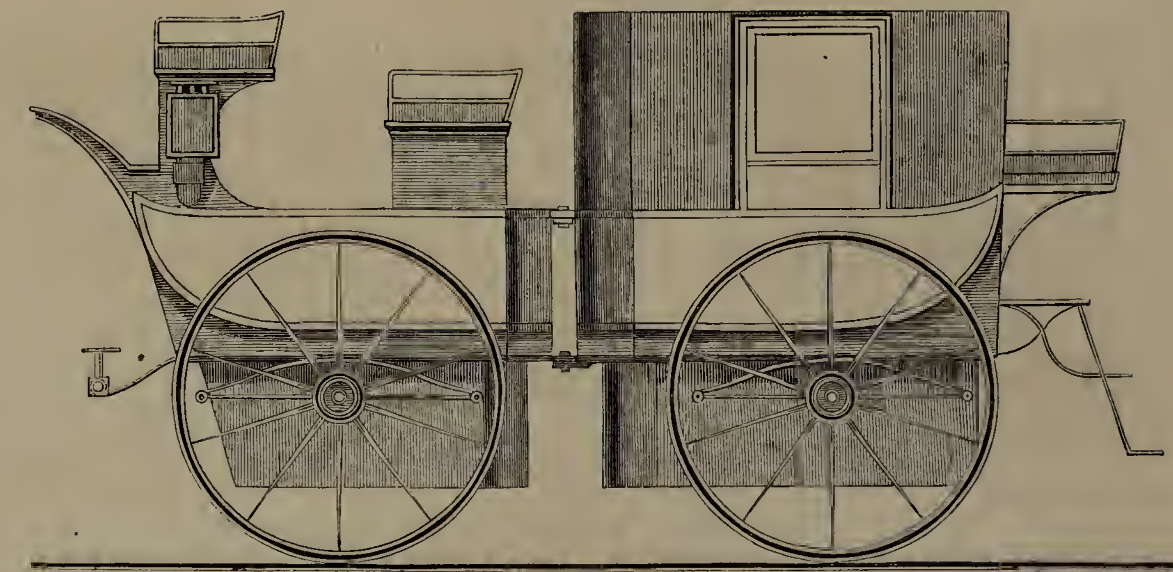
In the Turkish provinces proper (for Moldavia is only such nominally) the quickest mode of travelling is by *tatâr* (Fig. 909). A tatâr is a government courier, who carries despatches from one extremity of the empire to another, and who is also licensed to act as a guide to travellers. There are three kinds of passports current in Turkey, called respectively *teskeré*, *bigranti*, and *firman*. The second of these confers greater facilities and privileges than the first, and the third the greatest of the three. Provided with a firman, a traveller has a right to engage a tatâr as a guide and companion. At distances varying from three to sixteen hours apart on the great roads (reckoning distance by hours), there are stations or post-houses for the supply of relays of horses, both for the government service and for travellers provided with firmans. The tatârs are robust, active, cheerful, and in general trustworthy men, and are capable of performing a prodigious amount of travelling on horseback. On one occasion, when the British consul at Constantinople wanted to send news into Persia of the escape of Napoleon from Elba, he hired a tatâr, who traversed the distance of two thousand miles, over a very mountainous and dangerously rugged country, in seventeen days. Mr. Fraser describes, in his 'Winter Journey from Constantinople to Teheran,' the mode of tatâr travelling which he adopted, and which reveals an amount of peril and privation such as would damp the ardour of most adventurers. He describes the general dress of the tatâr couriers as having something peculiar and picturesque about it. Over the under clothing is worn a vest with long skirts, called a *jooba*, the upper part of which fits tightly to the shape, while the lower reaches down nearly to the heels in petticoat-like folds; the whole being richly embroidered with silk of a different colour. Around the waist is bound a girdle, a handsome silken shawl, and a leathern belt in which are stuck his pistols and yataghan. A jacket of scarlet cloth or velvet is worn over the vest; but his lower garments are more curious than elegant. His *shulwars*, or riding-trowsers, consist "of a petticoat of most prodigious dimensions, with the bottom sewed up, leaving two holes for the legs to go through. They are fastened round the waist by a running-cord, and being pulled up to the knee, where they are tied, are suffered to fall down almost to the ground; so that a person unaccustomed to them is forced to hold up the slack of them as he walks. It is a curious thing to see the manner in which a tatâr, as he mounts, stows away the multitude of his breeches before him; nor is it less curious to see the fashion in which he cords and bandages up his legs and feet to keep them from the cold, before he draws over all his huge and handsome embroidered stockings, which fall down with much stage effect over the front of his wide Turkish boots."

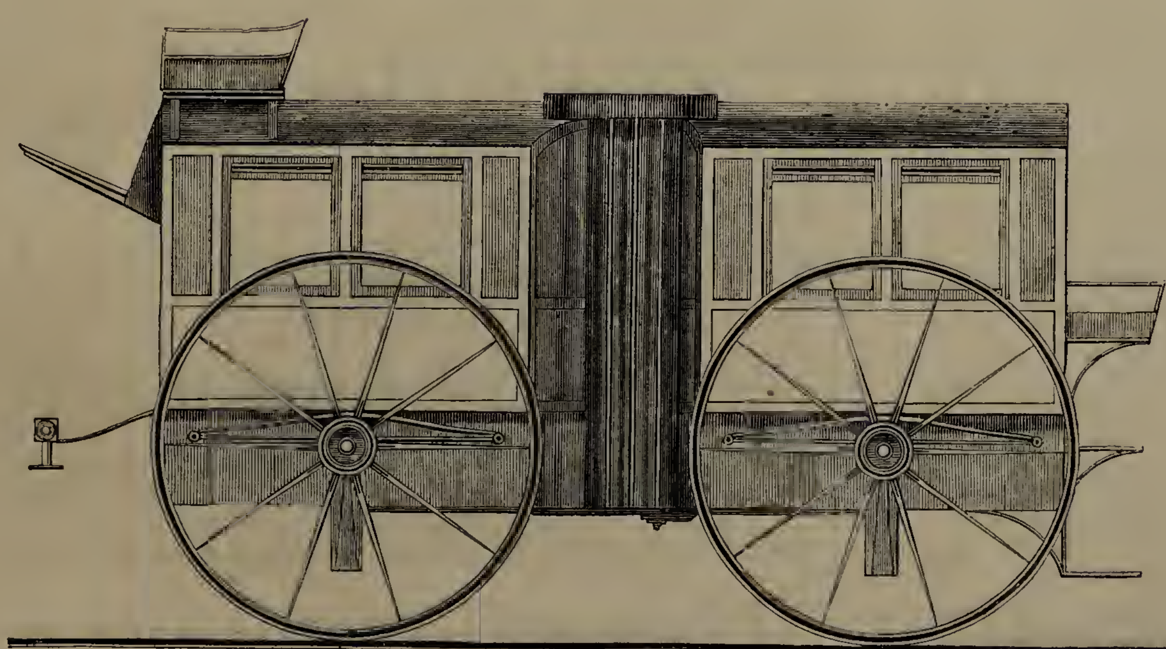
The Muleteer System of Spain.

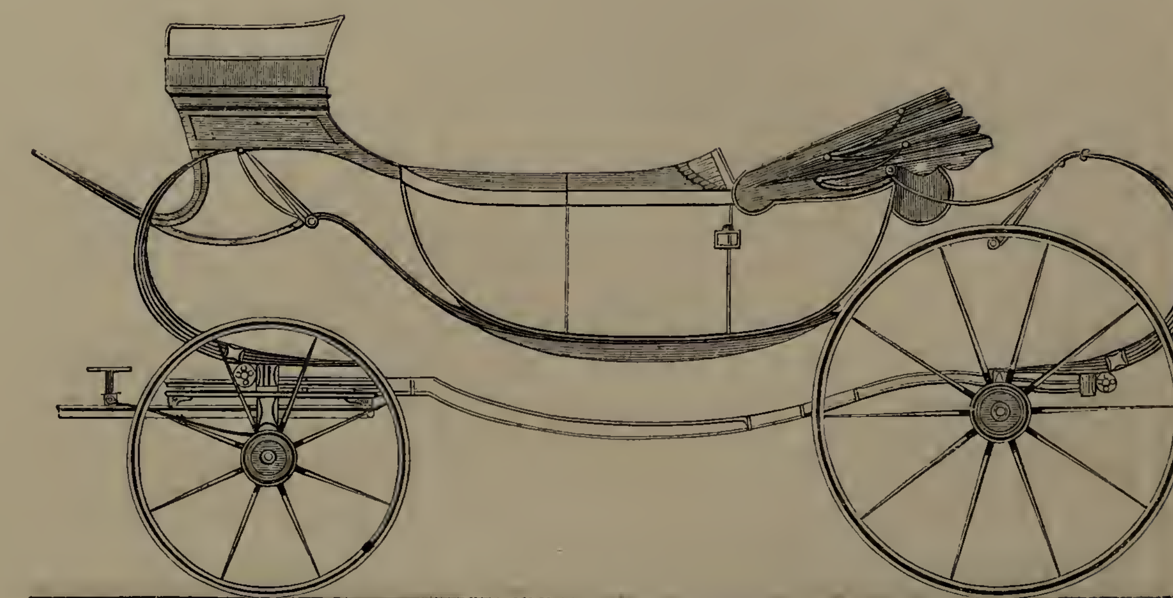
Spain, which resembles a half-civilised country in so many particulars, is in a very backward state in all that relates to roads and vehicles. Carriages are few in number and bad in construction; and the roads are even worse than the carriages. From various causes, mule-travelling may be regarded as the national one in Spain, and indeed the only one calling for notice here.

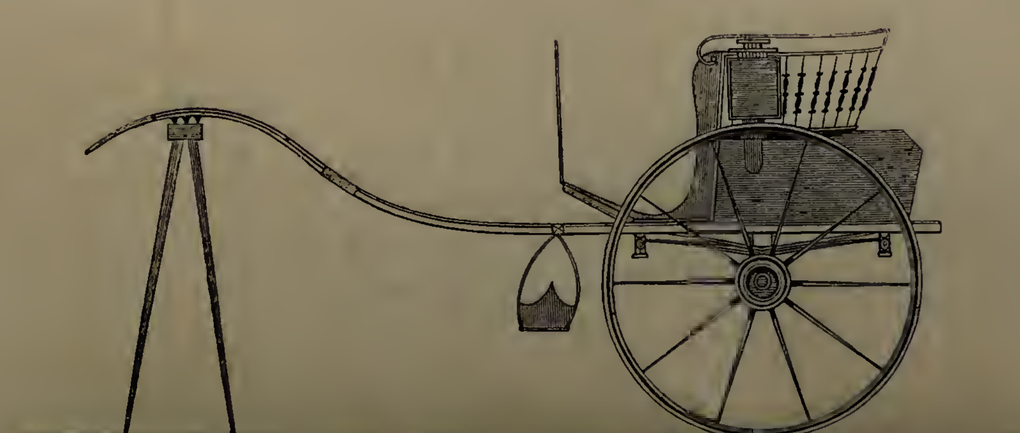
The *mule* is one of the most valuable animals in mountain districts as a means of travelling. Those reared in Spain have a sureness of foot, and a degree of unwearied activity, which render them almost indispensable in many parts of that country. The muleteers, or *arrieros*, as they are there called, form a numerous and conspicuous body in the population. Besides the mules ridden or driven singly, there are troops or caravans of mules (Fig. 901), which cross Spain on the various roads, carrying corn, rice, flour, pulse, wine, and oil in skins, and various kinds of goods from the sea-ports to the interior. "The muleteer," it has been observed, "is a primitive being; he wanders all over the vast peninsula; his home is everywhere; light-hearted and jovial, he is also honest, and his punctuality in general may be depended on. He is very kind to his mules, calls them by their names, talks to them, scolds them, and his first care on arriving at the inn is to see them comfortably provided for, and then, but not till then, he thinks of himself."

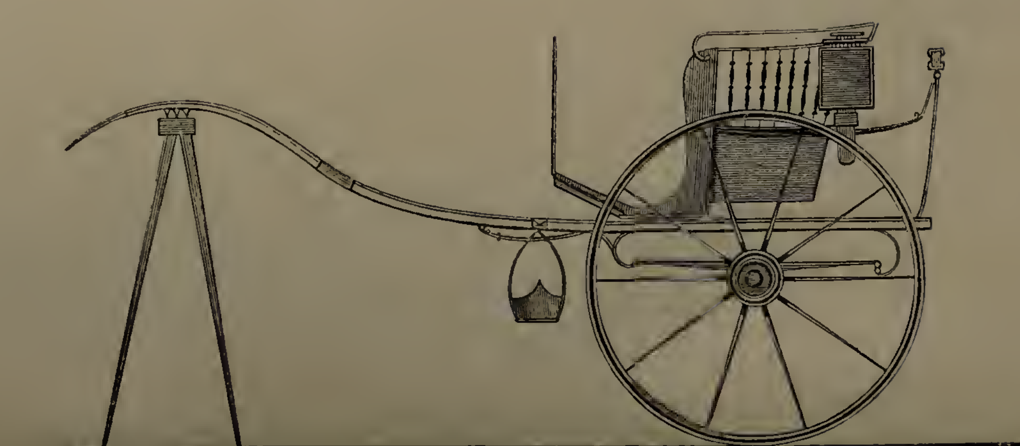

952.—Cabriolet.

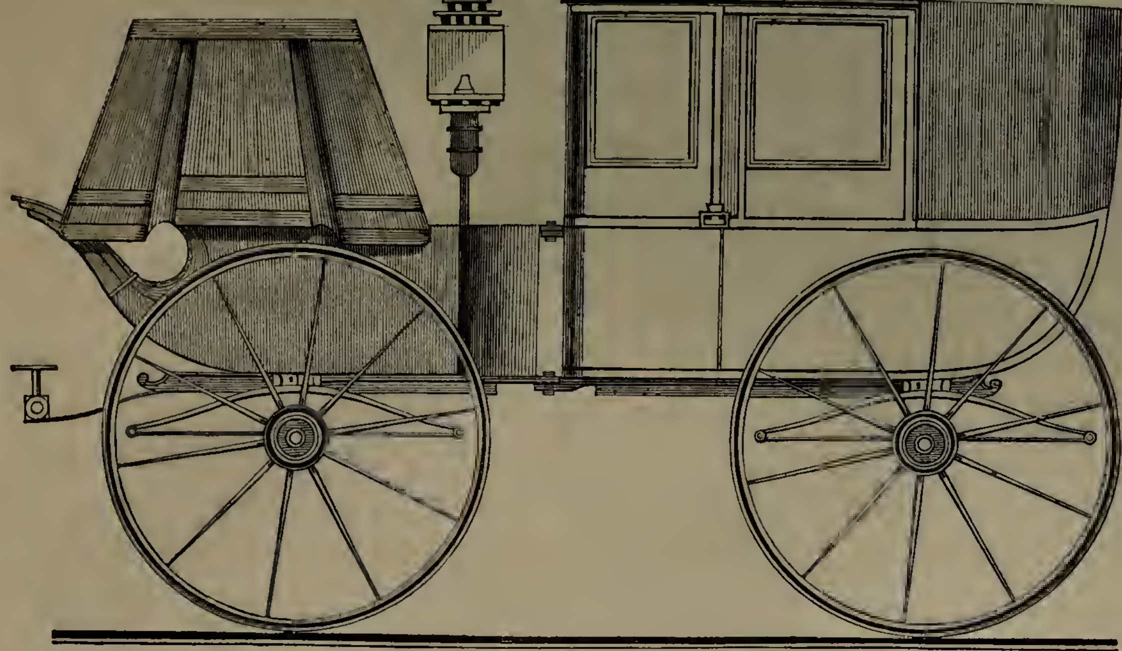

953.—Mail-Coach, with equal wheels.


954.—Omnibus, with equal wheels.

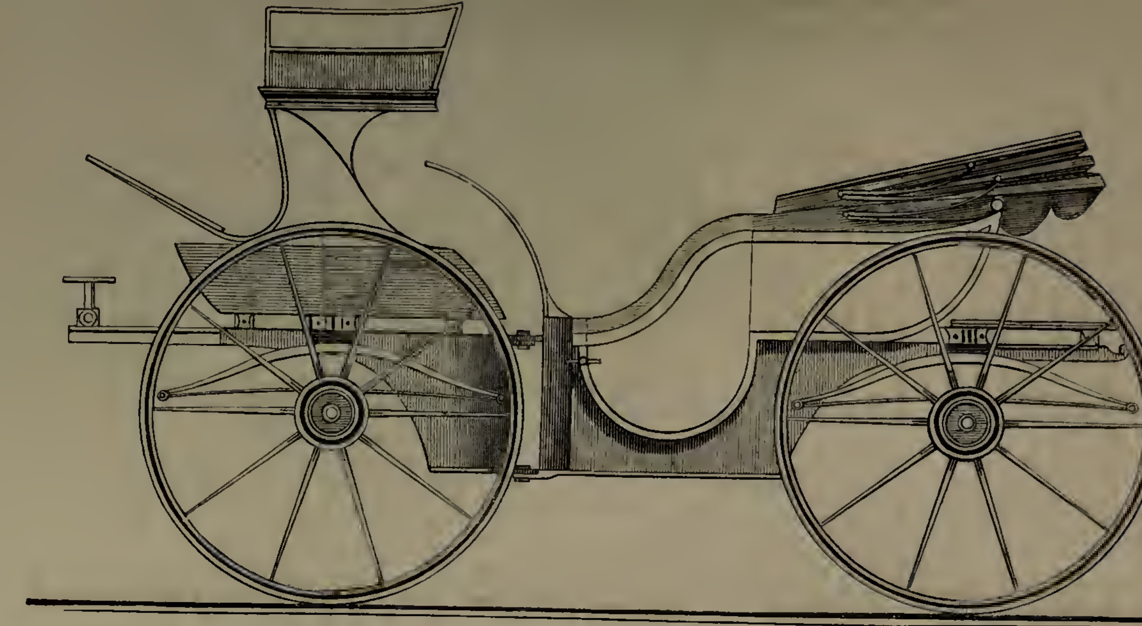

955.—Barouche.


956.—Stanhope.

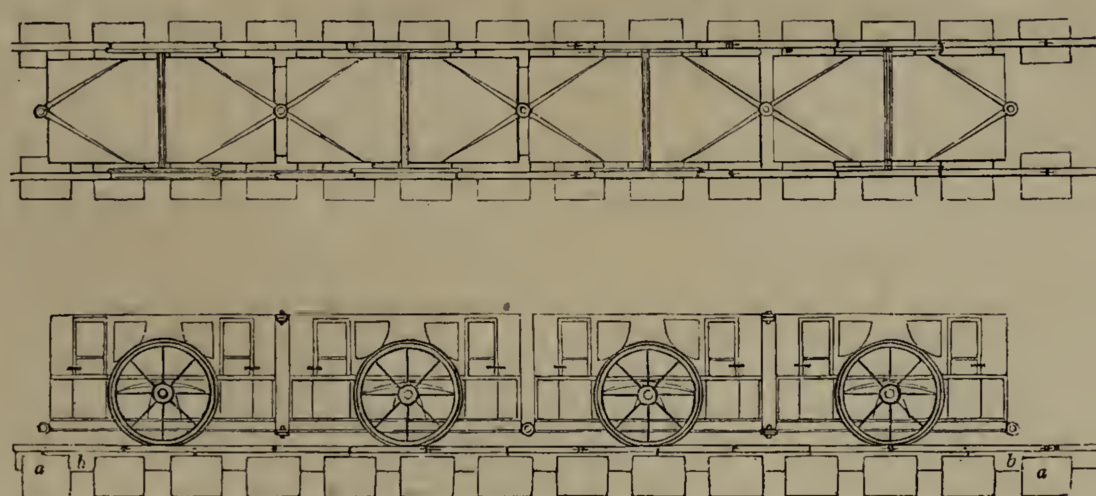

957.—Tilbury.



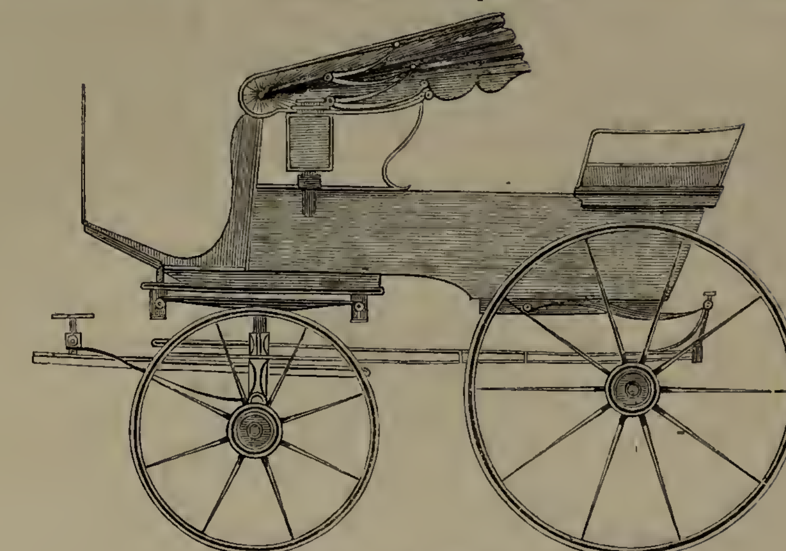
958.—Chariot, with equal wheels.



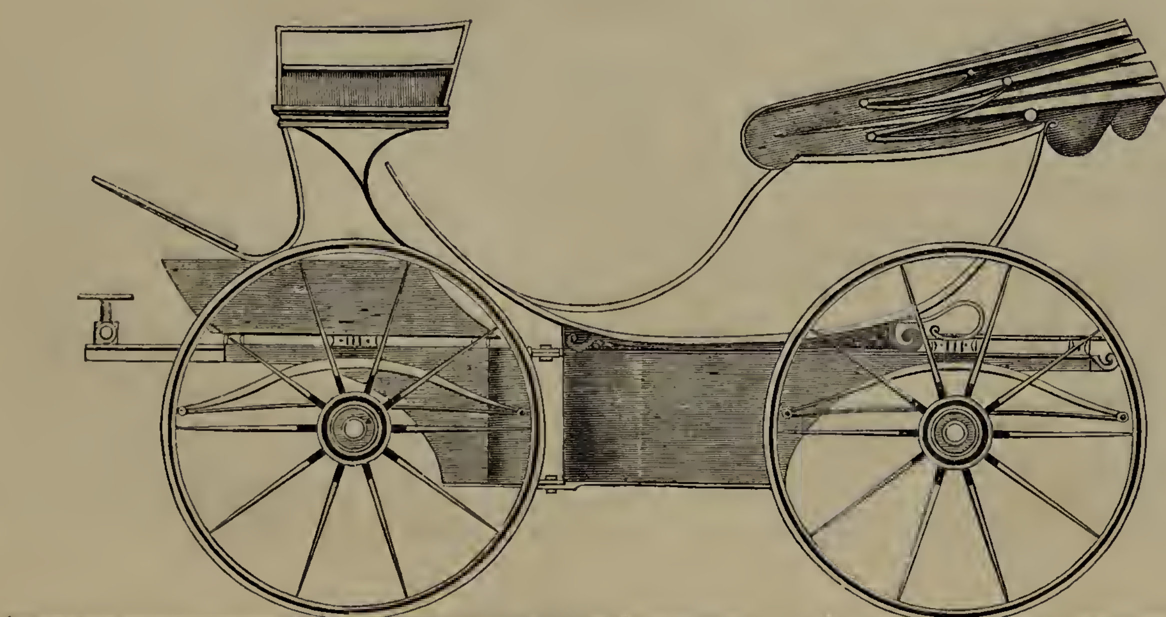
959.—Droitzschka, with equal wheels.



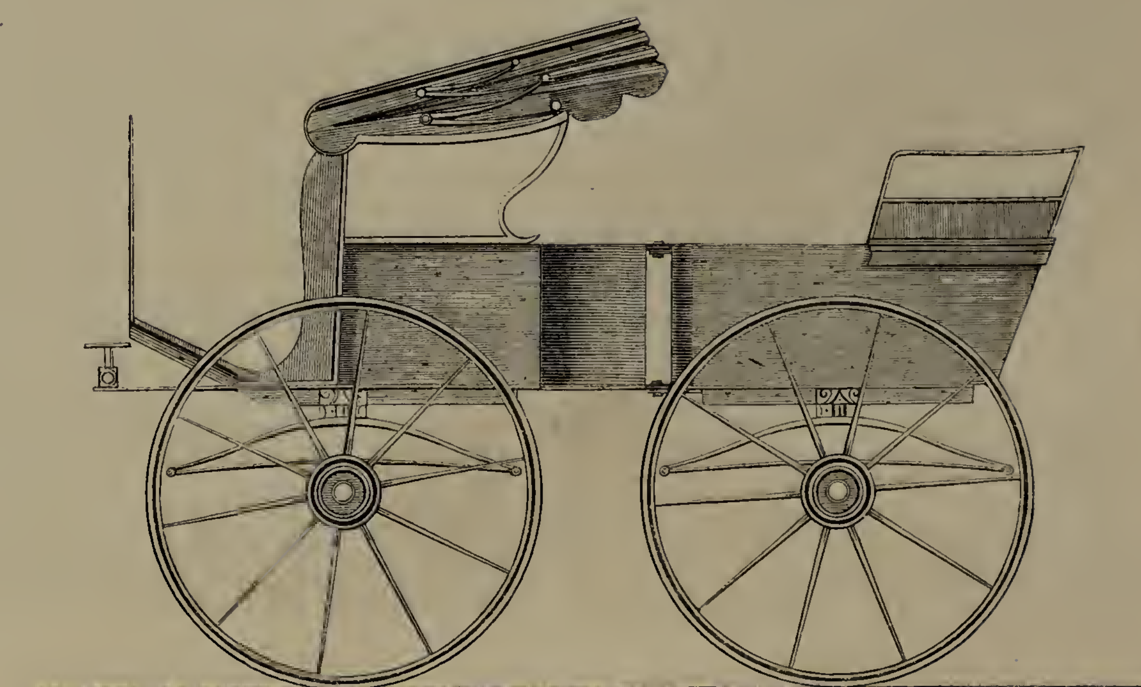
960.—Flexible Railway-train.



961.—Phaeton.



962.—Cab-Phaeton, with equal wheels.



963.—Phaeton, with equal wheels

The master muleteer has often a great many mules, which he lets out to various persons, sending his own servants with them. The working muleteers, or those who actually travel, pick up a little business on their own account, carrying parcels and executing commissions for persons on the road. During the Peninsular War the muleteers were much employed by the English to bring provisions from various parts of the country to the English armies. A troop of laden mules crossing a mountain district is sketched in Fig. 901.

Mr. Darwin, in his 'Narrative of the Surveying Voyages of the Adventure and Beagle,' describes the system of mule-travelling in South America. "Our manner of travelling," says he, "was delightfully independent. In the inhabited parts we bought a little firewood, hired pasture for the animals, and bivouacked in the same field with them; carrying an iron pot, we cooked and ate our supper under the cloudless sky, and knew no trouble. My companions were Mariano Gonzales, who had formerly accompanied me, and the 'arriero' with his ten mules and a 'madrina.' The 'madrina,' or godmother, is a most important personage. She is an old steady mare, with a little bell round her neck; and wheresoever she goes, the mules, like good children, follow her. If several large troops are turned into one field to graze, in the morning the muleteer has only to lead the madrinas a little apart and tinkle their bells; and although there may be two or three hundred mules together, each immediately knows its own bell, and separates itself from the rest. The affection of these animals for their madrinas saves infinite trouble. It is nearly impossible to lose an old mule; for if detained for several hours by force, she will, by the power of smell, like a dog, track out her companions, or rather the madrina; for, according to the muleteer, she is the chief object of affection. The feeling, however, is not of an individual nature; for I believe I am right in saying that any animal with a bell will serve as a madrina. In a troop each animal carries, on a level road, a cargo weighing 416 lbs. (more than twenty-nine stone); but in a mountainous country, 100 lbs. less. Yet with what delicate thin limbs, without any proportional bulk of muscle, these animals support so great a burden!"

While speaking of the Spanish and Portuguese provinces of South America, we may as well notice the "carri-coche" of Buenos Ayres (Fig. 913). It consists of a close-framed body, painted and lined, with sliding glasses, and a door to open behind, the whole suspended on long traces or twisted cords of untanned hide; when used in towns it is intended to be drawn by one or two horses with a postilion, and to carry six persons, three on each side, like an omnibus. As the body of the carri-coche is fixed on two braces nearly traight, and has little weight, the motion becomes very rough and unpleasant, except on a good road. Of the mode in which these and all other vehicles are driven in that country, Mr. Adams says:—"Horseflesh, owing to its abundance, is profusely wasted on the Pampas of La Plata (near Buenos Ayres). When used for draught, the horses are not harnessed: a strap or cord of raw hide is fastened to the ordinary saddle-girth; and as many as are the horses fastened to a vehicle, so is the number of the postilions. The possibility of one man guiding more than one horse when attached to a travelling vehicle has not entered into the imaginations of Spanish American economists. As for the collar, it is unknown."

Italian Vehicles.

The Italians were among the first to use coaches, and are in general very fond of riding. But, as may be supposed, in the wide space between Malta in the south and Milan in the north, the diversities are considerable.

The Maltese "calesse" is an uncouth-looking vehicle, slung upon a clumsy pair of wheels and shafts, and is made to carry four persons; but is always drawn by one horse, at whose side the driver runs. The English sailors, with whom Malta is a very favourite place, are frequently in the habit of hiring these vehicles for a ride, while having a short sojourn on shore; and the scene sketched in Fig. 936 depicts not inaptly the rollicking joyousness with which these light-hearted beings enter upon their trips.

The name of *Calesse* or *Calesso* is used in many parts of Italy for a carriage, and it seems to be a sort of generic name for them. In the 90th number of the 'Penny Magazine' was given a very good description of the several sorts of calesso or carriage used at Naples; and we cannot do better than avail ourselves of a few details from it.

The Neapolitans are exceedingly fond of driving—almost as much as of eating maccaroni. However much a nobleman may be impoverished in fortune, he keeps his stud and his carriages to the last, and even stints the daily economy of his household to retain the means of so doing. "The tradespeople and others, who will never walk when they can afford to pay for a ride, particularly on a holiday (and, besides the Sundays, there is some holiday or saint's day at least every fortnight, on an average), contribute to the support of an amazing number of hackney-coaches and cabriolets; and the very poorest of the people are as passionately fond of driving as their betters, and *do* contrive, by clubbing together, to indulge in that luxury on frequent occasions. It may thus be understood how Naples is more crowded with vehicles than any other of the European capitals." Some of the more common of these vehicles are very rough specimens of workmanship; but the best of them are said to excel in finish and completeness most others, except those of London.

The *Carozza d'afitto*, or the *carettella*, resembles in its object our hackney-coach, but is generally open at top, with a head which can be raised or lowered at pleasure: it is drawn by two horses. On general occasions the middle classes are the best customers to these vehicles; but on holidays, porters, washerwomen, and others of their rank, are found enjoying the ride in these hired vehicles. The *corribolo* answers to our hackney-cab, but is lighter and better shaped. A light body, capable of holding two passengers, is suspended on springs; one tough little horse runs in the shafts, and the driver sits on the shafts just before his fare. The body and wheels of the *corribolo* are always painted and varnished. The vehicle is generally driven with great rapidity, and, though a pleasant, is a somewhat perilous conveyance; it is in great request with the men of the middle classes, and, on holidays, with both men and women of the poorer class. The number of these vehicles at Naples is quite extraordinary, exceeding that of any of the other kind.

The *flower-pot calesso* is a very remarkable specimen of coach-building. The body, like a section of a large flower-pot, or inverted cone, cut perpendicularly in two, and hollowed out, is fastened to a wooden axle-tree. The horse is very loosely harnessed between the shafts; one, or sometimes two, passengers occupy the seat, whose entire weight rests on the axle, and only the weight of the shafts on the horse; then the driver leaps upon a narrow foot-board behind his passengers, and grasping the reins and flourishing his whip over their heads, sets off at full speed. From the counterbalance which the weight of the driver behind gives to the weight at the fore part of the vehicle, there is very little pressure on the horse's back, and he is thereby able to draw along the light vehicle with amazing rapidity. "When new, this particular vehicle is frequently very smart, and even gaudy, the wooden body being painted with flowers and coarsely gilt, the shafts and wheels as dazzling as bright red, yellow, and green can make them, and even parts of the shaft-horse's harness covered with gilding, very much like what is put on our gilt gingerbread-nuts. Unfortunately, however, as the Neapolitans choose gaudy rather than lasting tints, and as their colours are badly laid on, and the gilding most inartificially applied, their calessi soon look very shabby."

The *calesso*, however (of which a sketch is given in Fig. 929), is of all others the kind of vehicle with which the Neapolitans are best pleased. It is not so rapid as the others, but is more roomy, and on that account better adapted to accommodate a family. There may very often be seen in one calesso two or three persons on the seat; two or three more seated on the laps of the former, or by their feet at the bottom of the chaise, with, perhaps, their legs dangling down in front; three more hanging on behind; two boys or lazzaroni seated on the shafts; and a couple of little children fastened in a kind of net or bag, and hanging between the calesso and the ground. There may thus be twelve or thirteen pleasure-seekers packed together in this ludicrous manner; and to these is added the driver, who either stands up erect with the passengers, holding the reins and flourishing his whip over the heads of those who are seated within it; or, shortening the reins, places himself on the shafts close to the horse's croup. The calesso is generally drawn by two horses, one between the shafts and the other outside them; these are harnessed in the rudest manner by ropes and string, scarcely an inch of leather being visible: one consequence of which is, that the driver has to descend repeatedly from his seat to mend the broken and shattered harness. The body of the carriage is made wholly of wood, and is generally furnished with a hood of untanned hide, which can be brought over the heads of the riders; but it has no springs beneath, being slung on traces.

The writer of the article before alluded to relates an incident which well illustrates both the arrangement of the calesso and the kind of people who enjoy themselves in it. "The writer was going one morning on horseback from Castellamare to Pompeii, when he was stopped near a cantina or wine-house by the road's side, by hearing the most dreadful shrieks. As he approached the spot, he saw a calesso turn and drive back at speed; and on getting still nearer, saw a female peasant dressed in her gala clothes, who was tearing her hair and beating her bosom in a fearful manner. What was the matter? The calesso, crowded as usual on such occasions, was going to a festa or fair at the town of Nocera de' Pagani, and on stopping at that wine-house to refresh, it was discovered that the net below with the little boy in it was missing. The rope that held it had given way; and as the festive party were probably (as is usual with them when exhilarated by riding) all singing at the tops of their voices, the cries of the child were never heard. The afflicted mother was sure the '*guaglionciello*' (little boy) was killed; but presently a joyful shout was heard along the road, and the calesso, returning in company with another vehicle of the same character and similarly loaded, brought back the little urchin, covered indeed and almost choked with dust, but otherwise safe and sound."

Milan was celebrated for its coaches very early in the history of the use of such vehicles. From the old engravings of them occasionally seen, it appears as if one of the riders sat at the side door, where the steps of coaches are now placed; the coachman was seated very low; and the wheels were high and massive.

Vehicles of the Continent in general.

When we come to those parts of Europe which are frequently visited by Englishmen, we find vehicles in use bearing more or less a close relation to those of our own country; at least in so far as concerns the use of wheel-carriages drawn by horses. The arrangements depend a good deal on the circumstance whether the vehicles are owned or only hired by those who use them; a point which may be illustrated by the following rapid view.

The "mail" and "stage" coach systems on the Continent are not so complete as those to which we have been accustomed in England; and it is only in France, among continental countries, that they are tolerably complete. In France the *maille-poste* is a sort of stout barouche, able to contain usually only two inside passengers, while a third sits by the side of the conductor, outside and at the back of the carriage, the front seat being occupied by the driver. It is painted light red, and is drawn by four horses with tolerable harness; the rate of travelling is very swift, varying from nine to twelve miles an hour. The convenience of such a speed for travelling over a large territory like France, and the small number of places in each vehicle, render travellers desirable to secure seats many days beforehand. The maille-postes are kept up by the government, and carry the letters. When it is stated that the distance from Marseilles to Calais (not much short of eight hundred miles) is traversed in eighty-four hours, it will be seen that the speed vies with the best examples afforded in the palmy days of English "stages."

The diligences of the same country are, as to general object, equivalent to our stage-coaches, but much inferior. They have been characterized as "huge, heavy, lofty, lumbering machines, something between an English stage and a broad-wheeled waggon;" and they have four different classes of accommodation for passengers—the "coupé," the "intérieur," the "rotonde," and the "banquette." The arrangement may be described as comprising three distinct bodies, one behind another. The first one of these forms the "coupé," and is shaped something like a chariot or post-chaise, holding three persons, whose faces are towards the horses. The second body constitutes the "intérieur," and is equivalent to our "six-inside" coach; it is very closely boxed up, and is generally too hot and confined for the taste of English travellers. Behind this "intérieur" is a third body, the "rotonde," which is the general place for the humbler order of travellers—indeed it has been designated as the "receptacle for dust, dirt, and bad company." The "banquette" is a seat placed by the side of the conductor on the roof of the "coupé," exposed to the wind in part, but shielded from rain by a hood overhead; it is a favourite place for English travellers, who like to see the country before and around them. The difference of taste in the two countries is remarkably exemplified by this circumstance—that an English stage-coach has, at most, only six inside places to twelve out; whereas a heavy French diligence has fifteen inside places to four out. The harness employed to these vehicles, and the whole details of their make and finish, are far behind those of England. The rate of travelling seldom exceeds six or seven miles an hour, and generally falls short of this; the diligence, when fully laden, weighs more than ten thousand pounds, and in general requires either five or six horses to draw it. Nearly all the principal diligences, that is, those traversing the great roads of France, belong to two companies, the "Messageries Royales" and the "Messageries Générales;" and it is a feature worthy of English imitation, that every seat in every diligence is numbered, and the best secured to the earliest applicants.

The stage-coach system is not pursued much in Italy or Switzerland; but in the latter country coaches have been lately established by the governments of the respective cantons, to serve the purposes both of mail and of stage-coaches. The places are numbered, as in the French diligences, and are so far convenient; but the travellers have often to change coaches on leaving one canton for another, under circumstances of great delay and annoyance. In the southern parts of Germany the corresponding kind of vehicle is the "eil-wagen" or "quick coach:" these belong to the government, are under the management of government officers, and partake of the general strictness of Austrian arrangements. In Prussia the "schnell-post" is

nearly equivalent both in name and purpose to the "eil-wagen" of Austria; it is a roomy and comfortable vehicle, and is drawn at the rate of about six miles an hour. If the regular "schnell-post" cannot carry all the passengers who apply, the proprietors put on auxiliary vehicles called "bei-chaisen," which travel at the same rate and fares as the others. There is no outside travelling by these vehicles; and the inside places, as elsewhere on the Continent, are numbered. In Holland the stage-coaches are roomy vehicles, owned by private persons or by companies, and travel with three horses yoked abreast, at a rate of about six miles an hour. In Belgium the system is pretty nearly the same as in North Germany. In Russia stage-coaches have been established on the great roads within the last few years. Dr. Granville thus speaks of them:—"On the Riga and Moscow roads these vehicles are kept in excellent order, and perform their journey with great regularity: on the former road, in three days and nights (from St. Petersburgh); on the latter, in four days and three nights, stopping only for refreshments. The carriages are of considerable length, and are necessarily heavy; but their progress is not much impeded from that circumstance, and the speed is equal at least to any of the *voitures accélérés* in France. The rate of going is about seven English miles an hour. The diligence to and from Moscow sets off every day, carrying four inside, two in the *arrière cabriolet*, and one passenger with the conducteur."

All the vehicles above alluded to are such as perform regular journeys between and through certain towns, starting at fixed hours, performing the journey in a definite time, and carrying persons at a definite fare. There are, however, hired vehicles in use in all the countries we have mentioned, much more numerous than the regular stage-coaches, whether called by the name of "diligence," "eil-wagen," or "schnell-post." In the "posting" system, as generally understood in England, and as practised on the Continent, the traveller engages the whole vehicle for himself or his party, and goes where he will for as long a time as he will, under bargain with the owner.

In France there are not vehicles of definite shape for this purpose, such as English "post-chaises;" but the innkeepers in the large towns lend out carriages of various kinds, such as berlins, landaus, barouches, chariots, cabriolets, and caléches, at a price agreed upon between the parties. The "horsing" of these carriages, and also of private carriages, on the French roads, is regulated by a very strict system, under government control, as laid down in a published book called the 'Livre de Post,' or 'Post-Book.' The distances of the "postes," or stages, the number of horses for the kind of carriage employed, the mode of harnessing the horses according to their number, the charge per mile, the fee to the postilion, the rate of travelling—all are laid down in this book.

In various states of Italy and in Switzerland the system of post-travelling bears a resemblance to that of France in its chief features. In the dominions of the Pope, the posting belongs to the government, and is farmed out to other parties under very stringent regulations. Throughout the south of Germany the system is in rather a low state; the vehicles provided are open caléches or chaises, and the general arrangements are rather slovenly. In Prussia they are better; the post-masters are always respectable men, and are licensed by the government, under a very strict surveillance. In Russia, also, the system of posting seems tolerably well-conducted: chariots, berlins, caléches, britschkas, and low four-wheeled carriages called "kibitkas," being provided for this purpose.

Besides the stage-system, in which each person takes a place for himself, and the posting-system, in which one party engages the whole vehicle, there is in many parts of the Continent a system in operation midway between the two. In France, the *voiturier* is one who has a vehicle for hire, generally a kind of heavy cabriolet, which he will drive in any direction, and for any specified time, at a charge agreed on between him and the traveller, without the surveillance of the post-system. In Italy, the *vetturino* is a similar person, and the traveller proceeds in one of three ways:—1st, he takes a place with others who may happen to be going in the same direction; 2nd, he, alone or with a party, engages the whole vehicle at his pleasure; 3rd, he bargains with the driver to supply him with meals as well as travelling conveniences; the driver engaging to make all necessary arrangements at the inns on the road. The *lohnkutscher* of Germany is something akin to the voiturier or vetturino just named. He is one who has for hire a "lohnkutsch," usually a light sort of caléche or chaise, capable of being closed in with leathern curtains or glass windows, and of accommodating four or five persons. One person may hire the whole vehicle, or three or four may join who happen to be going the same way; and the journey may be made in any direction and for any time agreed upon.

There are various other vehicles in use on the Continent, which need hardly engage much of our attention. In Russia there are "droschkies," which go on wheels in the summer, and on a sledge in the winter; the traveller sitting astride on a cushioned seat which runs from front to back of the vehicle; and the "isvostchisk" or driver sitting in front. In the southern provinces of the Austrian empire rude vehicles are occasionally used, called "einspann," consisting of a sort of long wooden cart, with a single seat suspended by straps across the centre; or else there is a straw mattress to accommodate both driver and passenger. In Hungary there is a system in force called the "vorspann," which relates not so much to the kind of vehicle employed as to the means of "horsing" them; the peasants, under an arrangement which presses heavily and unjustly on them, are obliged to supply horses, even by taking them away from the plough, from station to station on the great roads, if the traveller happens to be provided with a sort of official passport called an "assignation." The "bauern-post" of Hungary is another system, established by the peasants between Vienna and Pesth; the traveller provides his own carriage, and these peasants provide horses, which they drive themselves at a very rapid rate. Mr. Paget describes this kind of travelling in very pleasant terms:—"The pace at which these men take on a light Vienna carriage is perfectly wonderful, especially when the length of some of their stages is considered. The last stage between Vienna and Pesth cannot be less than forty miles, and, with a short pause of about a quarter of an hour to water, they do it for the most part at full gallop, and with the same horses, in four hours. It is glorious to see the wild-looking driver, his long black hair floating in the wind, as he turns round to ask your admiration when his four little clean-boned nags are rattling over hill and dale at a pace which, for the first time since he left home, shakes an Englishman's blood into quicker circulation."

In Switzerland, and to a smaller extent in France, there is an open vehicle in use called the "char-a-banc." It is of two kinds: the larger consists of two or more benches suspended by thongs across a kind of long waggon, and ranged one behind another; the smaller one is a kind of gig placed sideways upon four wheels, at a little distance from the ground, and is surrounded by leather curtains made to draw aside when required—a construction which has earned for it the name of a "four-post bedstead on wheels." About equal to the "char-a-banc" in simplicity, though differing from it in shape, is the Irish "jaunting-car." Mr. and Mrs. S. C. Hall, in their work on 'Ireland,' describe these cars as being of three kinds. The "covered car" is a weather-proof variety of the open car, having curtains on all sides; it is used chiefly in the towns, for the same purposes as our hackney cabs. The "inside jaunting-car" differs only from the "outside-car" in being a little more enclosed at the sides, for both are open over-head. The last named constitute the general kind of cars in Ireland. They are very light vehicles, pressing but little on the horse, and are both safe and convenient. They are always driven with a single horse. The driver occupies a small seat in front, and the travellers sit back to back, with a space called the "well" between the two seats, for the reception of luggage. As the passengers sit sideways, they can see only one half of a street in a view, and this is rather a drawback in the estimation of travellers accustomed to look right ahead of their vehicle. If there be only one passenger, the driver usually places himself in the opposite seat to balance the car. There is a foot-board which comes down over full half of the wheel, and this gives such a great breadth to the vehicle that it is scarcely possible for an overturn to take place.

English Coaches in past times.

The early use of wheel-carriages in this country has been a matter of some antiquarian research. There were, doubtless, many stages in the progress to the costly equipages of late times. In the time of the Normans, the "horse-litter" was much used, but chiefly for ladies; it was a kind of sedan with double shafts, having two horses instead of two men to bear it, one before and the other behind. During the feudal times which followed, the knight scorned the effeminacy of such modes of conveyance, and thought the saddle the only worthy mode of travelling.

Both the country in which and the time when coaches were first used, have been much disputed—France, Italy, Spain, and Germany, all laying claim to the honour. Whatever may be the correct determination of these points, it is known that some sort of carriage, called a "caretta," was used in the thirteenth century, and that citizens' wives were wont to indulge in the use of such luxuries more frequently than was deemed proper by their liege lords. Mr. Adams describes an illuminated MS. of the date of 1347, in which a lady is shown seated in a carriage richly coloured; the outer edges of the wheels are coloured grey, to represent an iron tire; the horses are attached to the carriage by a similar method to one now in use; the body of the vehicle is of carved wood, and the hangings of purple and crimson, turned up in the centre; the lady is seated inside, with an attendant behind, and her fool or jester in front; the carriage, which seems to be shaped more like a cart than a coach, is drawn by two horses, the charioteer sitting upon the left horse.

As to the term *coach*, applied to closed pleasure vehicles, the derivations of the term are ludicrously numerous. "Kutten," "koetsen," "kotsee," "koteze," the Latin "carraca," and the Greek ὀχέω—all have been hunted out as affording the probable derivative; but be it what it may, it is probable that the varieties of "coach," "caroce," "carri-coche," "caretta," "char," "chare," "car," "chariot," "charat," "kutsch"—all obtained their names from the same source. The French "brouette" (Fig. 930), which preceded the general use of carriages in that country, was a whimsical medium between a coach and an invalid carriage of modern times; for it was a kind of sedan placed upon wheels, and drawn by a man in front.

It is said by Stow that coaches were not used in England till the year 1555, when Walter Rippon made a coach for the Earl of Rutland. This differs slightly from the account which Taylor the "Water-Poet" says; for he mentions the year 1564 as the year when a coach was first seen in England. The curious writer here named was a Thames waterman in the early part of the seventeenth century; and he committed to paper a long string of lamentations concerning the decay of his trade by the introduction of coaches. He says that Queen Elizabeth "had been seven years a queen before she had any coach; since when they have increased with a mischief and ruined all the best housekeeping, to the undoing of the watermen, by the multitudes of hackney-coaches. But they never swarmed so much to pester the streets as they do now till the year 1605; and then was the gunpowder treason hatched, and at that time did the coaches breed and multiply."

Whether one or the other of the above dates be correct, or both be wrong, it seems clear that the use of coaches spread very fast. Spencer speaks of "wagons," "coaches," and "chariots." Private families had their vehicles; and the taste for the luxury extended so far and wide, that a proposition was more than once made to prohibit their use, on the plea that government would be at loss to mount their cavalry, by reason of the great demand for horses.

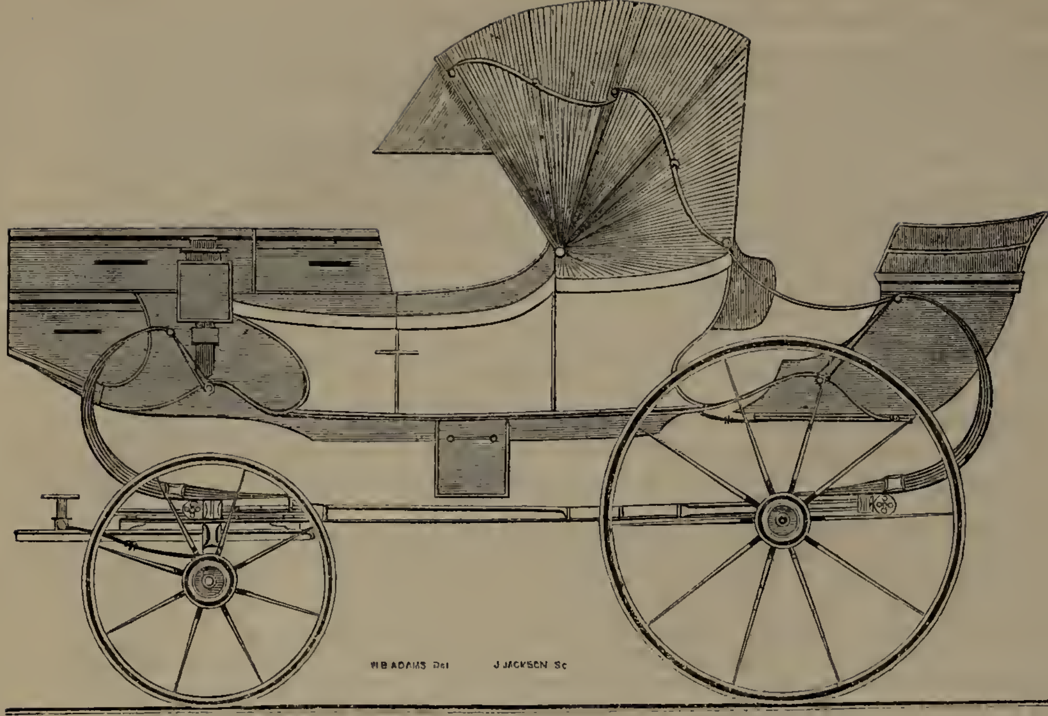
From the time of Elizabeth onward throughout successive reigns, the allusions to coaches and carriages in various writers are frequent. A witticism was published in 1638, called 'Coach and Sedan,' which purported to be the narrative of a dispute between two vehicles so named, as to relative excellence. One of the disputants, "Sedan," is described as being "in a suit of green, after a strange manner, windowed behind and before with isinglasse (probably talc), having two handsome fellows in green coats attending him; the one ever went before, the other came behind. Their coats were laced downe the back with a green lace suitable; so were their half-sleeves; which persuaded me at first they were some cast suites of their masters. Their backs were harnessed with leather angles cut out of a hide as broad as Dutch collops of bacon." The other competitor, "Coach," is described as being "a thick, burly, square-sett fellow, in a doublet of black leather, brasse-buttoned downe the breast, back, sleeves, and winges, with monstrous wide bootes fringed at the top with a net fringe, and a round breech guilded, and on the back an achievement of sundry coats in their proper colours, &c. Hee had only one man before him, wrapt in a red cloke, with wide sleeves turned up at the bands, and cudgelled thick at the back and shoulders with broad shining lace (not much unlike that which mummers make of strawen hats); and of each side of him went a lacquey, the one a French boy, the other Irish, both suitable alike."

The various changes that took place in the coaches and vehicles of successive generations cannot be better shown than by illustrations taken from old books. Although the reign of Queen Elizabeth is mentioned as that in which coaches, properly so called, were introduced, there were other kinds of vehicles in use before that time. In Figs. 927, 930, 938, 939, 940, 943, 944, 947, we find various kinds of sedans represented—one drawn on wheels, the "brouette;" others carried by men who hold by handles or shafts in their hands; others borne by horses; and another (Fig. 939), the elegant sedan of Queen Elizabeth, borne on men's shoulders. Various forms of wheel-carriages are shown in other cuts; such as those in Figs. 937, 943, 944, 945, 947, 949.

English Coaches and Vehicles for Hire.

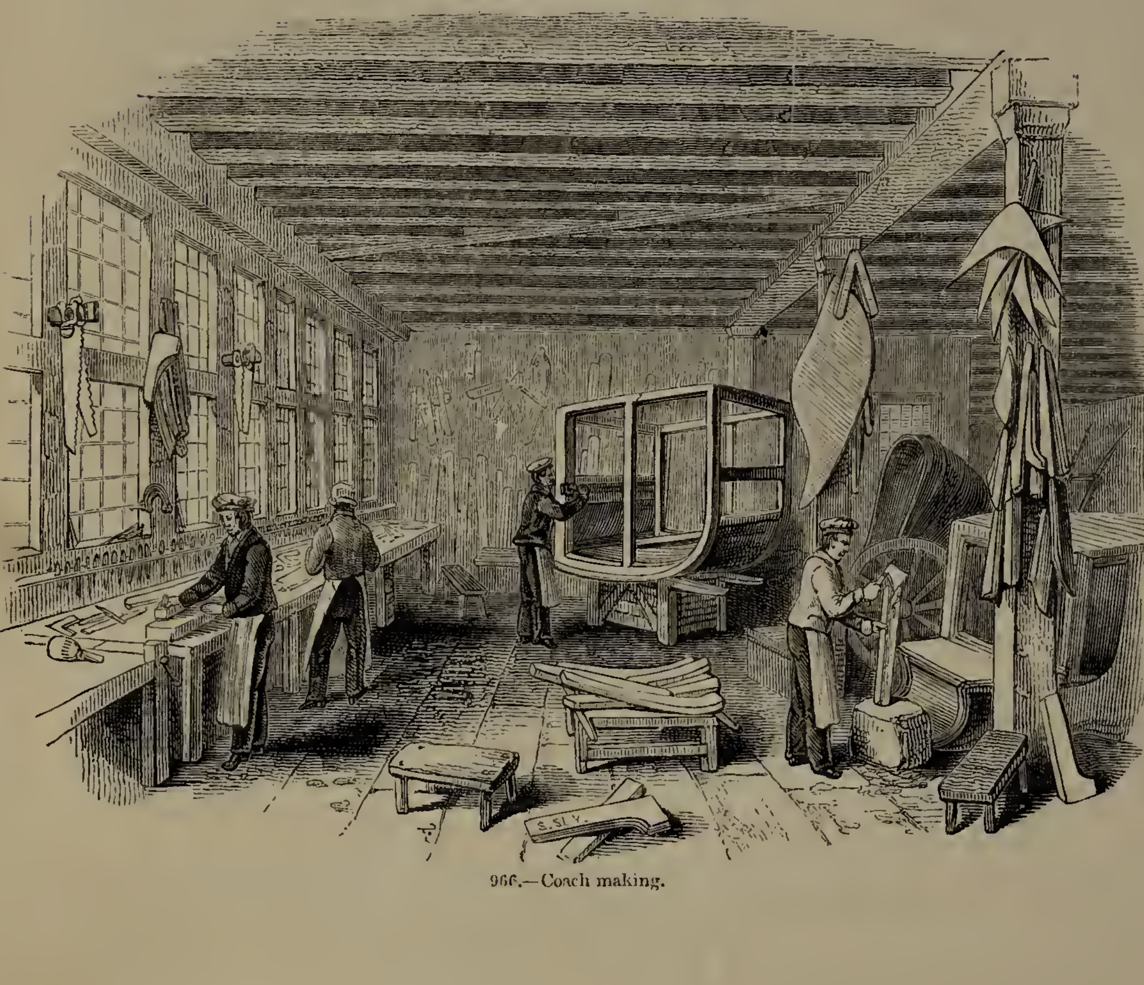
Although, as an index to the state of luxury among the wealthy classes, the successive improvements of private carriages is an important feature, the advancement of commercial activity and intercourse is more fully illustrated by those vehicles which do not belong to those who customarily ride in them; such as *mail* and *stage coaches*, *hackney-coaches*, *cabriolets*, and *omnibuses*.

Stage-coaches, at whatever date they may have been first introduced, did not acquire much importance till the reign of Charles II. But in that reign the number had become so large, that many of the tradesmen of London

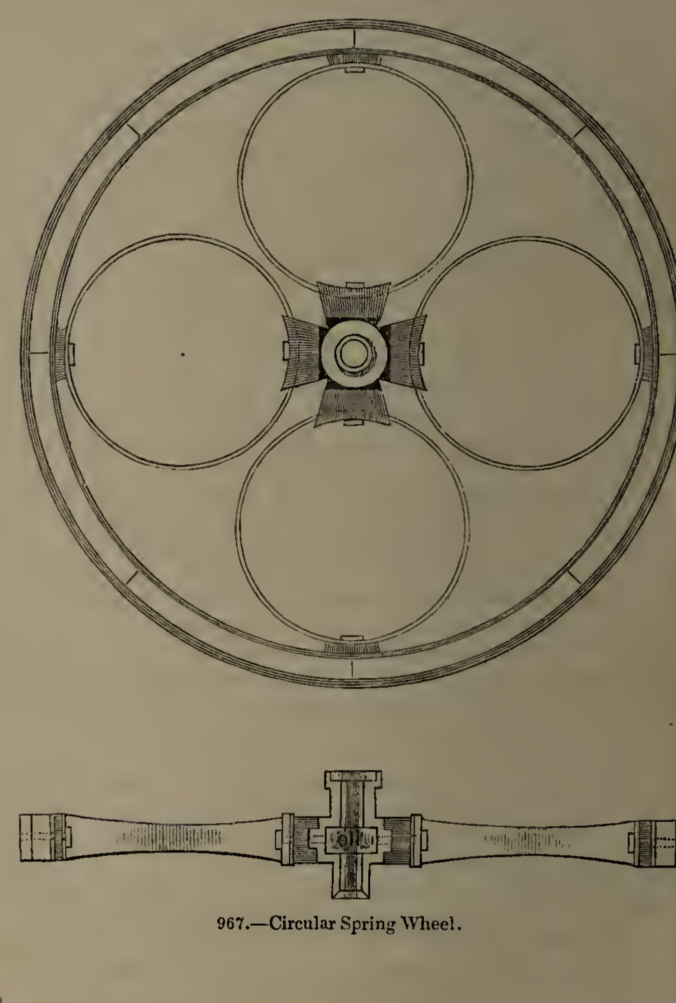


964.—Britzschka.

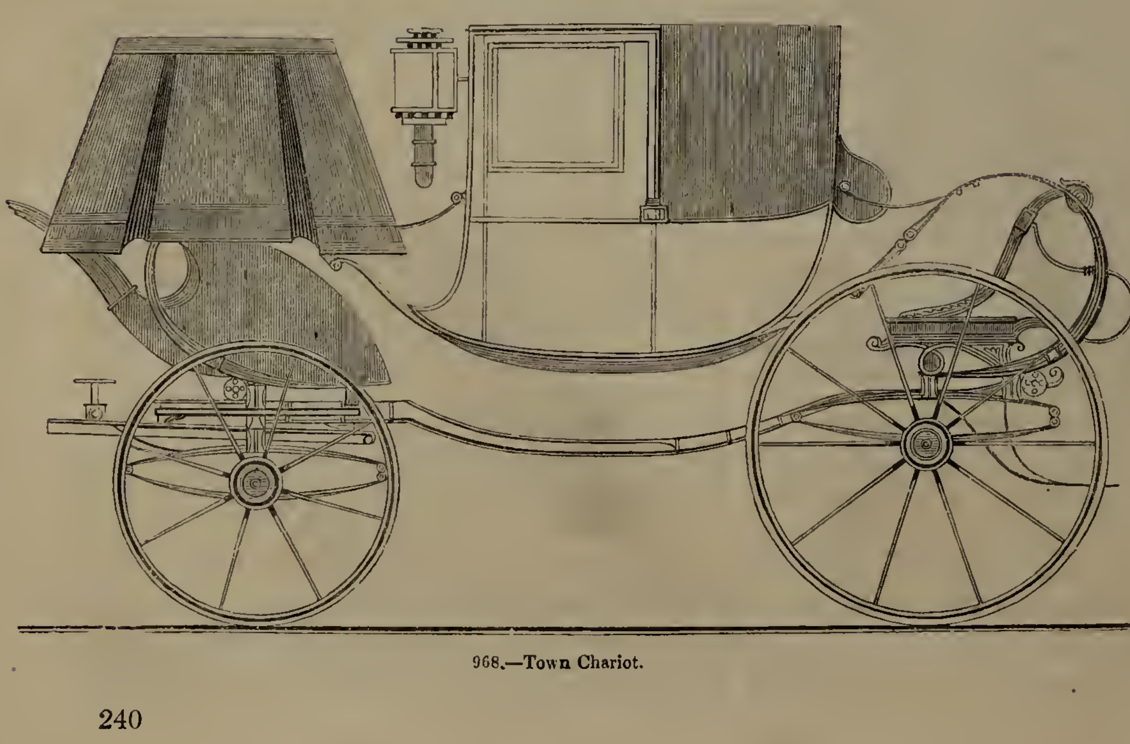
965.—Making Coach-spring.



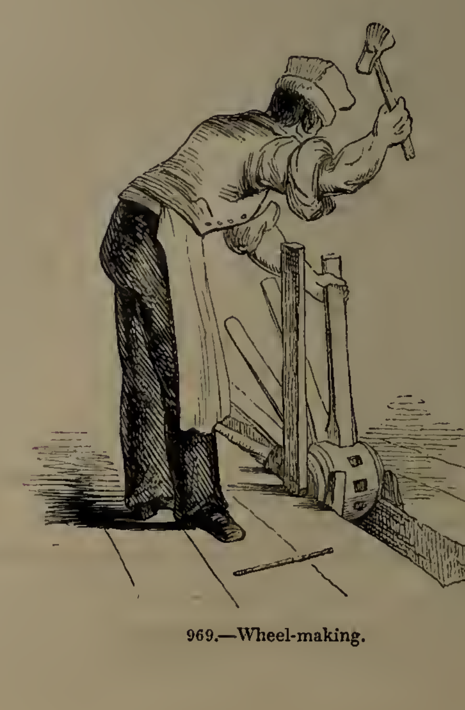
966.—Coach making.



967.—Circular Spring Wheel.



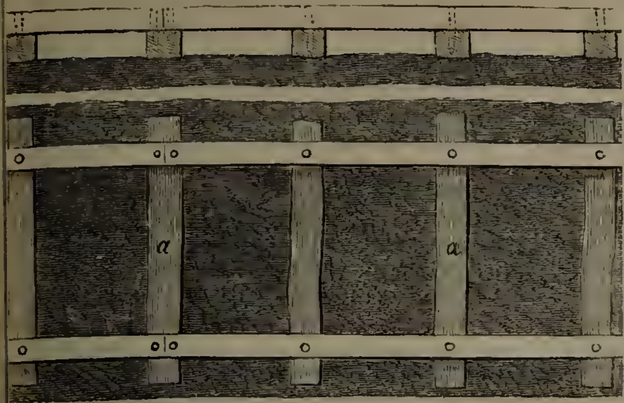
968.—Town Chariot.



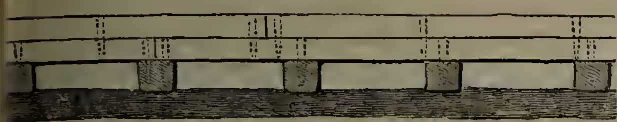
969.—Wheel-making.

970.—Moorish Arch, Liverpool and Manchester Railway.

971.—Olive Mount Cutting, Liverpool and Manchester Railway.



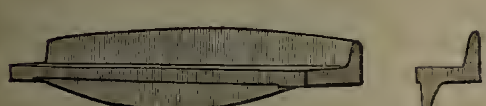
972.—Primitive Wooden Railway.



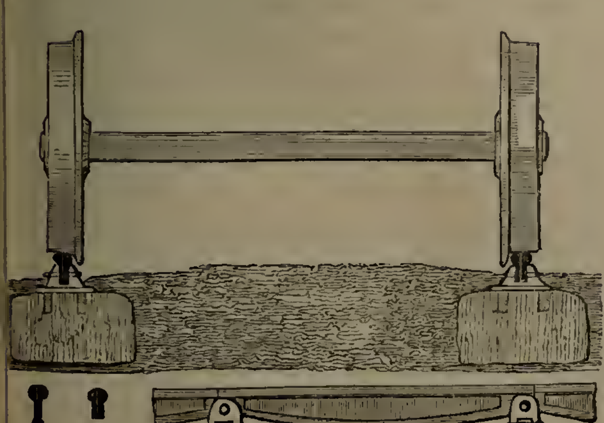
973.—Primitive Wooden Railway.

974.—Rails and Permanent Way.

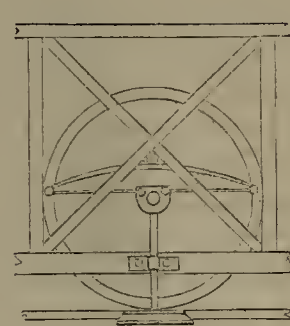
975.—Rails and Permanent Way.



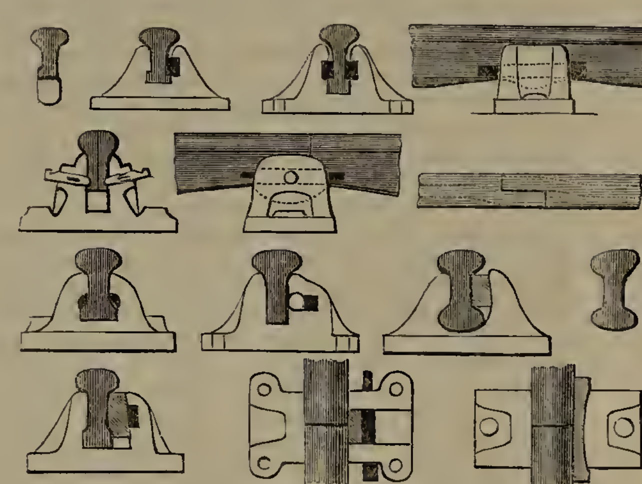
976.—Form of Railway Bar.



977.—Rails and Permanent Way.



978.—Proposed Guide-Wheel for Railways.



979.—Sections of Railway Bars and Chairs.

thought proper to petition the King and Privy Council against them: under the several pleas that these coaches injured the rents and profits of inns, lowered the value of farming produce, and inflicted injuries in various ways. A counter memorial was presented by the coach-owners, either denying or explaining away the several charges. Like other instances of the same kind, this opposition to the spread of a public good was fruitless, and the use of stage or hackney coaches (for at first there was no essential difference between them) gradually extended.

According to an Itinerary published in 1603, it appears that at that time there were post-houses established on the great roads at intervals of about ten miles apart, for supplying horses to travellers who went on horseback. There were also carriers who had "long covered waggons, in which they carry passengers from city to city; but this kind of journeying is very tedious, for they must take waggon very early, and come very late to their inns; so that none but women and people of inferior condition travel in this sort. Coaches are not to be hired anywhere but at London; and although England is for the most part plain, or consisting of little pleasant hills, yet the ways far from London are so dirty that hired coachmen do not ordinarily take any long journeys." Another work, but of a more querulous kind, published in 1673, in the midst of a great mass of grumbling and discontent, gives a few facts worth noticing. "York, Chester, and Exeter stage-coaches, each of them with forty horses apiece, carry eighteen passengers a week from London to either of these places, and the same number in return from thence to London. There are also other coaches which, with four horses and carrying six passengers, go daily to places within twenty and thirty miles of London, and others that go and return the same day from places within ten miles. There are stage-coaches that go to almost every town within twenty or twenty-five miles of London, wherein passengers are carried at such low rates that most persons in and about London, and in Middlesex, Essex, Kent, and Surrey, gentlemen, merchants, and other traders that have occasion to ride, do make use of, who, before these coaches did set up, kept a horse or two of their own, but now have given over keeping the same." Another passage gives us a little insight into the fares charged by stage-coaches at that time. "From London to Exeter, Chester, or York, you pay 40*s.* apiece in summer, and 45*s.* in winter, for your passage; and as much from those places back to London. Besides, in the journey they change coachmen four times, and there are few passengers but give 12*d.* to each coachman at the end of his stage; which comes to 8*s.* backward and forward, and at least 3*s.* comes to each passenger's share to pay for the coachman's drink on the road; so that in the summer the passage backward and forward to either of these places costs 4*l.* 11*s.*, and in winter 5*l.* 1*s.*; and this *only for eight days' riding in summer and twelve in the winter!*" How would the writer have marvelled to be told of a 'Great Western' train running from London to Exeter in four hours and a half! As a means of mitigating the nuisance of which he complains, the "Lover of his Country" (for so the writer designates himself) suggests as follows:—"If some few stages were continued, to wit, one to every shire-town in England, to go once a-week backward and forward, and to go through with the same horses they set forth with, and not travel above thirty miles a-day in the summer and twenty-five in the winter, and to shift inns every journey, that so trade might be diffused, there would be sufficient to carry the sick and the lame, that they pretend cannot travel on horseback; and, being thus regulated, they would do little or no harm; especially if all be suppressed within forty or fifty miles of London, where they are no way necessary, and yet so highly destructive."

The hackney-coaches, plying for hire in any required direction, kept pace with the stage-coaches. It is said to have been about the year 1634 that a "coach-stand" was established in London. In one of 'Strafford's Letters,' written about that time, the matter is thus alluded to:—"I cannot omit to mention any new thing that comes up amongst us, though ever so trivial. Here is one Captain Baily, he hath been a sea-captain, but now lives on the land, about this city, where he tries experiments. He hath erected, according to his ability, some four hackney-coaches, put his men in livery, and appointed them to stand at the May-Pole in the Strand, giving them instructions at what rate to carry men into several parts of the town, where all day they may be had. Other hackney-men, seeing this way, they flocked to the same place, and perform their journeys at the same rate. So that sometimes there is twenty of them together, which disperse up and down, that they and others are to be had everywhere, as watermen are to be had at the water-side. Everybody is much pleased with it." The hackney-coachmen of those days were equipped with spurs (Fig. 941), and rode on one of their horses in threading the intricate streets of London.

Hogarth's pictures furnish abundant illustrations of the kind of stage and hackney coaches in use during the greater part of the last century. An anonymous writer has thus described them:—"In my young days stage-coaches were constructed principally of a dull black leather, thickly studded, by way of ornament, with black broad-headed nails, tracing out the panels; on the upper tier of which were four oval windows, with heavy, red wooden frames, or leathern curtains. Upon the doors also were displayed, in large characters, the names of the places whence the coach started, and whither it went, stated in quaint and antique language. The vehicles themselves varied in shape. Sometimes they were like a distiller's vat, somewhat flattened, and being equally balanced between the immense front and back springs. In other cases they resembled a violoncello-case, which was, past all comparison, the most fashionable form; and thus they hung in a more genteel posture, namely, inclining on the back springs, and giving to those who sat within the appearance of a stiff Guy Fawkes uneasily seated. The roofs of the coaches, in most cases, rose into a swelling curve, which was sometimes surrounded by a high iron guard. The coachman and the guard, who always held his carbine ready cocked upon his knee, then sat together; not, as at present, upon a close, compact, varnished seat, but over a very long and narrow boot, which passed under a large spreading hammer-cloth, hanging down on all sides, and finished with a flowing and most luxuriant fringe. Behind the coach was the immense basket, stretching far and wide beyond the body, to which it was attached by long iron bars or supports passing beneath it; though even these seemed scarcely equal to the enormous weight with which they were frequently loaded. These baskets were, however, never great favourites, although their difference of price caused them to be frequently well filled. The wheels of these old carriages were large, massive, ill-formed, and usually of a red colour; and the three horses that were affixed to the whole machine—the foremost of which was helped onward by carrying a huge, long-legged elf of a postilion, dressed in a cocked-hat, with a large green and gold riding-coat—were all so far parted from it by the great length of their traces, that it was with no little difficulty that the poor animals dragged their unwieldy burden along the road. It groaned and creaked at every fresh tug which they gave it, as a ship rocking or beating up through a heavy sea strains all her timbers, with a low moaning sound, as she drives over the contending waves."

It is a curious circumstance that, as much as half a century ago, a single-horse hackney carriage (Fig. 948) was proposed in London, approaching singularly near in construction to one of the forms of "cab" used in our own day; although in the intervening time nothing of the kind was at all known. In No. 2 of 'London' it is stated:—"We have before us the copy of a drawing in the splendidly illustrated Pennant in the British Museum, in which we see Temble Bar with heads still blackening upon spikes over the arch, and beneath it a carriage of which that below (the one alluded to) is an exact representation. There is also a print without a date, giving the same delineation of the same vehicle; and this tells us that it is the carriage of the ingenious Mr. Moore. Like many other 'ingenious' persons, Mr. Moore was before his age; and in another half-century his carriage, or something very like it, finds favour in our eyes as one of 'Patent Safety.'"

Coach-Statistics in the present Day.

Railways are causing such an overturn in the general management of travelling and vehicles, that every year now affords a diminution in the number of "long stages," and an increase in the number of cabriolets and omnibuses. It may be well therefore to give a few details of the actual condition at a given time.

Mr. Porter, in the second volume of his 'Progress of the Nation,' gives a general view of the stage-coach trade in the year 1834, which was a very fitting year for this purpose, since it just preceded the mighty changes wrought by the opening of so many railways. Mr. Porter states, that upon making a calculation for the whole number of stage-coaches that possessed licences at the end of that year, it appears that the means of conveyance thus provided for travelling are equivalent to the conveyance, during the year, of one person for the distance of 597,159,420 miles, or more than six times the distance between the earth and the sun. It has been found that the degree in which the public avail themselves of the accommodation thus provided is in the proportion of 9 to 15, or three-fifths of its utmost extent. Following this proportion, the sum of all the travelling by stage-coaches in Great Britain may be represented by 358,295,652 miles. If we exclude from the calculation all very young children, as well as persons who from their great age and bodily infirmities are unable to travel, there will probably remain in England 10,000,000 of persons by whom that amount of travelling might be accomplished; but it is well known that a very large proportion of the population are not placed in circumstances that require them to travel, and, if even it were otherwise, that they would not avail themselves of a mode of conveyance so comparatively costly as a stage-coach. For these reasons, Mr. Porter infers that the number of stage-coach travellers does not exceed 2,000,000; and he adds, "it places in a strong point of view the activity which pervades this country, when we thus arrive at the conclusion that each of those persons must on the average travel on land by some public conveyance 180 miles in the course of the year." This calculation is exclusive of all travelling in post-chaises, or in private vehicles, and is besides confined merely to England alone, embracing very little of Scotch traffic, and none of Irish. Two-thirds of the entire mileage above given was found to be performed by stage-coaches which had London for one of their termini, thus placing in a striking light the immense traffic which entered and left the metropolis every day.

In two clever articles recently published in 'Chambers' Edinburgh Journal' (Nos. 76 and 78, New Series), on the "Vehicular Statistics of London," there are some interesting details concerning the metropolitan omnibuses, hackney-coaches, and cabs, from which we may condense a few particulars.

Omnibuses, like many other conveniences of life, owe their origin to the ingenuity of one who has failed to reap an adequate reward. "In July, 1829" (we quote from the first of these two articles), "a coach-proprietor named Shillibeer started the first omnibus that ever successfully plied in this country. Such carriages had long been common in Paris; but when, so far back as 1800, a similar vehicle was put upon the road in London, with four horses, it looked so exceedingly like a hearse, that people would not ride in it. The peculiar advantage of Shillibeer's carriage was its great capacity, which enabled him to accommodate from seventeen to twenty persons, at but little greater expenditure than what was required by the old stage-coaches to convey twelve or fourteen. This caused an important reduction in the fares. Again, at least ten of the passengers were protected from bad weather; whilst, by the old system, not more than four, or at most six, could ride 'inside,' and that at nearly double the cost of outside places. Shillibeer made no difference in the charge; his omnibus was therefore much patronized. It ran between Greenwich and Charing-Cross, and was drawn with three horses abreast; but this was found not to answer, the middle horse being always severely distressed by the irregular stepping and perspiration of its neighbours. After some of the new vehicles began to run on the Paddington Road—which success between Greenwich and Westminster soon led to—only two horses were used, as now."

The coach-proprietors found themselves forced, by degrees, to give up their "short stages," and adopt omnibuses instead. For many years a fearful scene of competition ensued in the chief routes of London, by the racing of omnibuses against each other; but by a coalescence of the opposing parties the chief traffic is now in the hands of large companies or bodies of proprietors, who lay down very stringent rules for the management of the traffic. In 1836 the first of these companies was formed, and it led to the formation of others. There is one great route from Paddington to the Bank, through Oxford Street and Holborn; this route is in the hands of a company which possesses upwards of eighty omnibuses; a thousand horses; as many conductors, drivers, and horse-keepers, as there are omnibuses; and a staff of farriers and assistants. Each omnibus makes on an average six journeys a-day; and the whole number of omnibuses make nearly 500 journeys, and go over 2200 miles of road every day. The omnibuses start from each end, from nine in the morning till about ten at night, at intervals apart never exceeding three minutes, and generally less than two.

Another powerful association possesses the route from Paddington to the Bank by way of the New Road and the City Road. This body possesses about sixty omnibuses, with an equal number of drivers, conducters, and horse-keepers, and a stud of horses in proportion. There is in respect to this, as to the other company, a curious variation arising out of the railway system. The London Bridge station of the four Surrey and Kentish railways, and the Fenchurch Street station of the Blackwall Railway, bring up to town vast numbers of persons, some of whom are glad to avail themselves of omnibus conveyance to various parts of London; and the arrangements are so conducted, that while some of the omnibuses terminate their route at the Bank, others proceed to the Blackwall Railway, and a third set to the London Bridge railways. From this system results an amount of public convenience scarcely to be appreciated, except by those who watch the results and compare them with past times.

Other great omnibus routes have been established, whereby the metropolis is becoming intersected with them in all directions. One route is from the neighbourhood of Lisson Grove to Kennington, over Waterloo Bridge; another, from Camden Town and King's Cross to Kennington, over Blackfriars Bridge; a third, from Holloway and Islington over the same bridge to the same terminus; a fourth, from Islington, through Regent Street and Knightsbridge, to Chelsea; others, from Chelsea, from Putney, or from Kensington, right through London from west to east, even to Mile End and Blackwall. There are others of a similar kind, having for their object the establishment of a

route almost completely through London in one direction or other; besides those which pass to and fro all day long between some particular part of London and the villages by which it is so thickly surrounded.

It is supposed that at the present time there are about 1400 omnibuses plying in the metropolis; the receipts from which amount to about 2000*l.* per day, or 730,000*l.* per year—nearly all in sixpences!

The other varieties of public vehicles—hackney-coaches and cabs—though not so remarkable as the omnibuses, have partaken of considerable changes within the last few years. Until the year 1823, the hackney-coaches with two horses had a monopoly of this kind of trade. As far back as the year 1661 there were 400 licensed hackney-coaches, the proprietors of which paid a yearly tax to the government as an equivalent for their monopoly—no others being allowed than those to whom licences were granted. This number increased to 700 by the year 1694, to 800 by 1714, and to 1000 by 1768; about which last-mentioned year coach-stands were regularly established. The vehicles in use down to 1823 were always either "coaches" or "chariots," both of which kinds were usually left-off private carriages, too often shabby and ill-conditioned. The coach had two seats, and was licensed to carry four, though six frequently used it; the chariot had but one seat, intended to carry two persons, but often accommodating three.

It was in the year 1823 that an attempt was successfully made to break through this monopoly, by the establishment of vehicles similar to the French "cabriolets de place," of which eleven or twelve hundred plied in Paris so far back as thirty years ago. The innovation was strenuously resisted by the old coachmen, but public convenience decided the question; and from that time the sun of the old system has set. The new single-horse vehicles, by driving rapidly and charging only two-thirds of the coach fare, have been in such large demand that the number at present plying in London is said to exceed 2400. Their shapes have been very varied: some have had two wheels, some four; in some the driver has been by the side of his fare, in others in front, in others behind, and in others perched on the top; some have been open, some partially closed, and others wholly closed; some have been likened to a "slice taken from an omnibus," some have resembled a chaise, while some (at the present day) are really neat and well-finished close carriages. But all are alike in this, that they are drawn by one horse each, and may be hired for two-thirds of coach fare.

The hackney-coaches have dwindled from twelve hundred to two hundred, and have all the features of a worn-out race. The second of the articles before alluded to in 'Chambers' Journal' gives a capital sketch of a coach-stand in the olden time:—"A hackney-coach-stand presented a picture of perfect repose. The horses stood motionless, and were either fast asleep, like their masters on the box, or stood quietly munching chopped hay out of nose-bags suspended from their heads. The coachman sat under the weight of a heavily caped 'box'-coat, either in a state of profound reflexion or of nodding somnolency. When, therefore, any one wanted his services, it was necessary to bawl with might and main; but as that very often proved ineffectual, the attendant 'waterman' of the stand was often obliged to use active measures to wake him. Having recovered from his reverie, or his nap, the driver slowly rolled himself off his seat, and, assisted by the waterman, removed the nose-bags, or awoke the horses, and dragged them by the head-gear to the side of the pavement; the door-steps were then leisurely unfolded, and the 'fare' or passenger helped in. If the animals were thought to want water, a few minutes were occupied in giving it to them, and after the coachman had handed the waterman his 'rent'—a perquisite of one halfpenny, receivable every time a coach left the stand—the wheels were made to revolve at the rate of about three miles an hour. So notoriously slow were the motions of these vehicles, that when a coachman of extraordinary activity carried his enterprise so far as to solicit custom by saying to a passer-by, 'Coach, sir?' the reply frequently was, 'No, thank you—I am in a hurry.'"

Varieties of English Vehicles.

The number of persons to be accommodated, the number of horses by which the vehicle is to be drawn, the mode in which the horses are to be harnessed, and the general purpose of the vehicle—all determine the shape adopted. Mr. Adams, in his 'Treatise on Pleasure Carriages,' describes most of the varieties; and to his descriptions and woodcuts we shall be indebted for a few details of information.

The *cabriolet* (Fig. 952) is a French improvement on the old "one-horse chaise," and has been much used in modern times for its convenience. It will accommodate two persons, sheltered from sun and rain, yet admits plenty of air, and may be made almost closed by curtains in front. It is said, however, to be a heavy vehicle, and to require a powerful horse to work in it continually; indeed, two or three horses are required if the cabriolet be constantly in use. The peculiar features of this vehicle are, that the body is curved somewhat like the nautilus-shell; the knee-flap or covering in front is stretched tightly across a frame; the shafts are in general gracefully curved; and the body is thrown rather back in respect to the wheels.

The *tilbury* (Fig. 957), named from a coach-builder of that name, is used on account of its great lightness. It was, as first used, built without springs between the shaft and the axle; but springs were afterwards employed to prevent the jar or jolting. The *Stanhope* (Fig. 956) bears a good deal of resemblance to the tilbury. It rests on two cross-springs, whose ends are suspended from two side-springs; by which means the body is placed at two removes from the concussion; but the shafts, and consequently the horse, are exposed to the whole of it.

The *barouche* (Fig. 955) is an open carriage with four wheels, much used formerly, but now to some extent suspended by the *britzschka*. The body of a barouche is made nearly like that of a coach without the roof; it has two seats, like a coach; and when the head is thrown back, and the knee-flap elevated, it will hold four or six persons inside. Occasionally, the barouche is fitted with a mahogany roof and sides, to close against the head or hood, and provided with glass windows. The *britzschka* (Fig. 964) was introduced about twenty years ago from Germany. The peculiarity of this vehicle is that it affords means for those within to recline at full length, or to sit, at pleasure; while there is considerable room for luggage, and facilities for making it a close or an open vehicle according to the state of the weather and the taste of the travellers.

A *coach*, used as a distinctive name for one particular kind of vehicle, is, as every one knows, a close carriage, for two or more horses, with two seats. A *chariot* (Fig. 968) is a smaller vehicle of the same kind, but having only one seat within instead of two. A *landau* is a coach provided with a jointed head, so that it can be thrown open in fine weather. A *landaulet* is a smaller vehicle of a similar kind, bearing the same relation to a landau that a chariot does to a coach. A *phaeton* (Fig. 961) is a double-bodied, four-wheeled, open carriage, less used now than before the introduction of the britzschka; it is intended to carry four persons, and has conveniences for stowing away a good deal of luggage for travelling.

The *droitzschka*, or more familiarly the *drosky*, is a vehicle introduced a few years ago from Russia. As used in that country it is in its simplest form very little other than a sledge placed upon springs and wheels, the single passenger sitting with his legs on each side of the perch, as if he were on horseback. But the droitzschka, as made in England, is only a modification of the britzschka, less convenient for most purposes.

There are many other forms of carriages, midway in object and shape, between those above noticed. The *town-coach*, the *travelling-coach*, the *dress-chariot*, the *cab-phaeton*, the *britzschka-chariot*, the *britzschka-phaeton*, are all varieties or combinations of the simpler vehicles. The *barouchet* is a small and light barouche, bearing the same relation to it as the landaulet does to the landau. The *curricle* is a two-wheeled carriage, drawn by two horses abreast. The *dennet* has a body in some degree resembling that of the phaeton, but smaller and lighter.

The two most notable vehicles in England, perhaps, are the "Lord Mayor's state-coach" and the "Royal state-coach;" both of which huge masses of ornament are wheeled through the London streets a few times in the year. With respect to the first of these, and the civic dignity for whom it is intended, it has existed very little less than ninety years. The Lord Mayors of London used formerly to go to Westminster on horseback, on the day of "swearing in;" but the Mayor for 1452, Sir John Norman, introduced the water pageant and procession, as being much more imposing, the distance to the water-side being travelled on horseback. This plan continued in operation till 1712, when a splendid state-coach was provided for the street cavalcade; four horses were at first used, and afterwards six; and in some of Hogarth's pictures we have an opportunity of seeing the kind of coach presented in his day. The present coach was built in 1757, by subscription among the aldermen; and each successive Lord Mayor bore the expense of keeping it in repair. It afterwards became the property of the Corporation, and has been frequently renovated and beautified since: the body and framework are profusely carved and gilt; and the panels contain allegorical paintings from the pencil of Cipriani. But though very gorgeous, it is less elegant than the "Royal state-coach," which was built very soon after it, at the commencement of George III.'s reign. This coach was planned by Sir William Chambers, and painted by Cipriani. The carriage is supported by two carved cables, fastened to four Tritons at the corners; the framework consists of eight palm-trees, which expand at the top to support the roof; while the spaces between the palm-trees form the panels, which are glazed above and painted below; on the centre of the roof are three figures, representing England, Scotland, and Ireland, supporting the imperial Crown and other insignias of royalty. This coach is said to have cost nearly 8000*l.*; of which 2500*l.* was for carving only.

In all four-wheeled vehicles in common use the front wheels are smaller than the hind. This is a necessary mode of construction, to enable the vehicles to turn. If the axle connecting the two front wheels be permanently parallel to the other axle, the vehicle could only turn by means of a sliding motion instead of a rolling one, thereby entailing an enormous amount of friction. To obviate this difficulty, the front axle is made to turn on a pivot, in such a way that while the whole carriage is turning the two axles are not parallel. But here another difficulty arises. The body of a four-wheel carriage is always so hung, that if the front wheels were as large as the hind ones, they would strike against the body while turning, instead of passing beneath it. Hence the use of small front wheels, and hence an unequal amount of action and friction on the various parts of the carriage.

To remove these defects, Mr. Adams has invented a mode of construction to which he applies the name "*equirotal*," that is, having equal wheels. The general plan consists in making the under carriage in two distinct parts, pivoted together so as to turn easily. The body of the carriage is generally attached to the hinder of these two parts; while the driver's box, or some other part of the fittings, is attached to the front one. The front wheels are of the same size as the hinder, since the pivot enables them to turn without coming into contact with the body. The manner of carrying the plan into execution is shown in some of the cuts. In Fig. 953 is shown a mail-coach on this construction; in Fig. 954, an omnibus, with a curious kind of vertical hinge in the centre; in Fig. 958, a chariot; in Fig. 959, a droitzschka; in Fig. 962, a cab-phaeton; and in Fig. 263, a phaeton. It will be easily seen, in these several examples, how the object is proposed to be carried out. In Fig. 960 the same principle is applied to the carriages of a railway-train. This equirotal contrivance seems at present to be rather a suggestion for future taste to adopt than one actually practised.

The Construction of Vehicles.

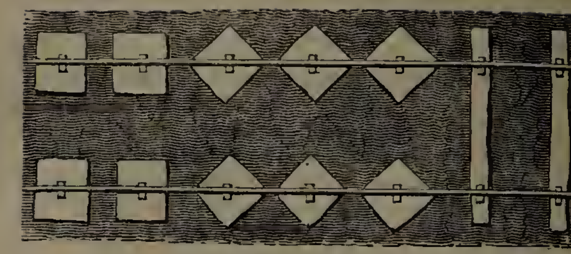
The various mechanical modes of working in wood and iron are nearly all brought into use in the making of a coach or other vehicle. The "body" and the "carriage," to use the technical terms of the makers, are wholly distinct, and made by different classes of workmen. The body is the part in which the passengers sit, while the carriage is the whole assemblage of axles, perch, &c., beneath.

The wood employed in coach-making is ash, beech, elm, oak, mahogany, cedar, deal, pine, fir-tree, larch-wood, and birch. Ash, from the character of its grain, is fitted to make the greater part of the framework. Elm is employed for the strong planking of the coach, and for the naves of the wheels. Oak is used for the spokes of the wheels, and for a few other purposes. Mahogany forms the panels or broad plain surfaces of the body. Cedar is sometimes employed instead of mahogany, when the panels are to be covered with leather instead of being painted. Deal and pine are used for the flooring and roof of carriages. The other woods are employed less frequently.

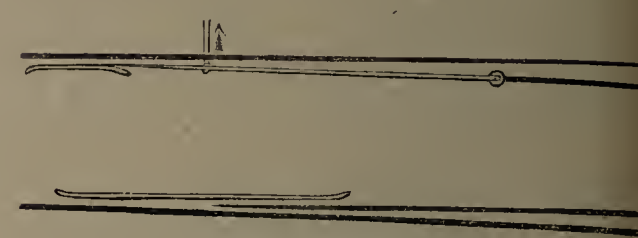
In making all the several parts of a vehicle, the saw, the plane, and other tools are used in the same way as in carpentry, or rather in joinery. A pattern or design of the coach is in the first instance made of the full size; and from this design the workmen proceed. Some of the thinner pieces of wood require to be bent by steaming, to fit them for use; and the adjustment of them all in their proper places requires very careful joining. The complexity of the framework beneath the body depends a good deal on the kind of carriage. Where there are four wheels, the under-mechanism is of necessity much more intricate than when there are only two. To connect the fore and hind axles a pole is wanted called the "perch;" which perch is made sometimes of wood and at others of iron, and is either straight or curved according to the kind of vehicle. The axles themselves differ rather according to the costliness than to the shape of the vehicle. The axle, under the designation of the "axle-tree," used to be made wholly of wood; but it is now generally of iron, or at least contains a good deal of that metal in its construction. In former times the axle was made to revolve with the wheels; but under the improved modern plan the wheels are made to revolve *on*, and not *with* the axle; and very careful mechanism is required in the arrangement of the revolving parts.

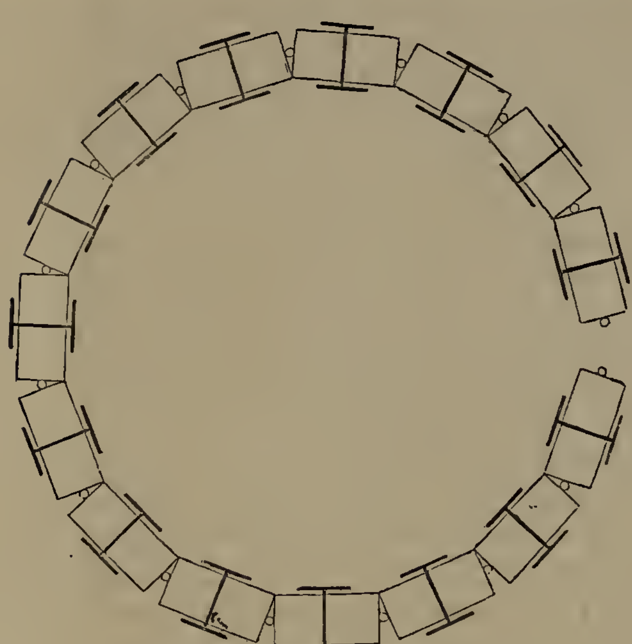
When the wood-work of a coach is pretty well completed in "the coach-maker's loft," as it is generally termed (Fig. 966), the covering, the painting, the trimming, and various subsidiary processes are carried on. The covering means the envelope of leather which is generally seen on the upper part of the best coaches, lying close to the wood-work of the roof, and the higher parts of the sides, back, and front. This is done in a singular manner. A large and sound ox-hide, being thoroughly moistened, is thrown over the coach, and allowed to hang down on all sides. The workman,


980.—Entrance of the Tunnel at Edge Hill, Liverpool.

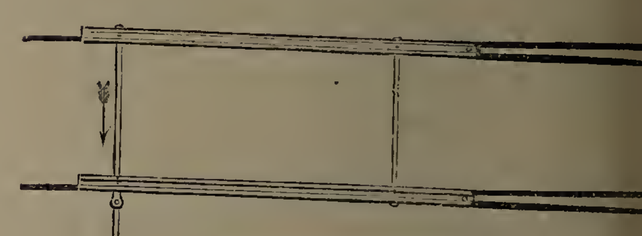

983.—Rails and Bearers.

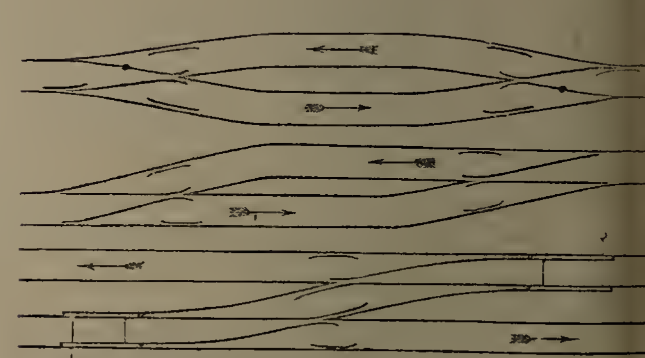

984.—Rails and Fastenings.


985.—Railway Switches and Points.


988.—Flexible Railway-train, drawn into a circle.

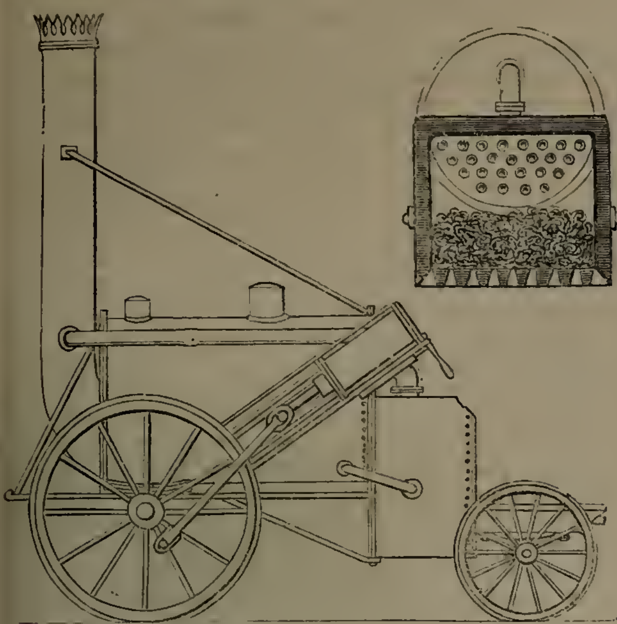

989.—Railway Turntables.


986.—Railway Switches and Points.


987.—Railway Switches and Points.

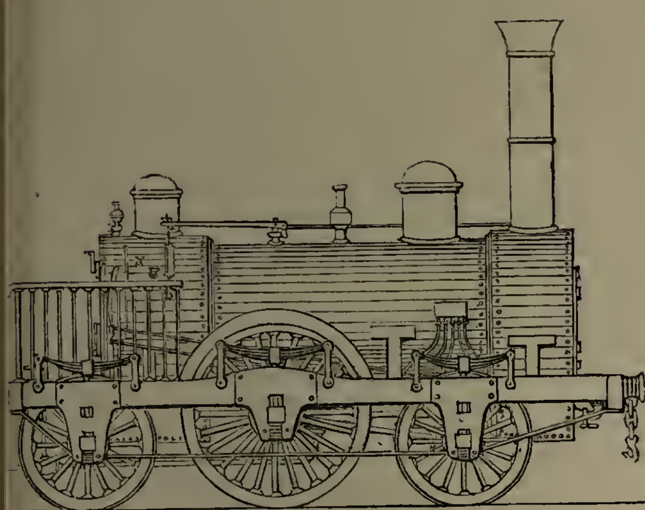

981.—Sankey Viaduct, Liverpool and Manchester Railway.


982.—West London Railway near Kensall Green.



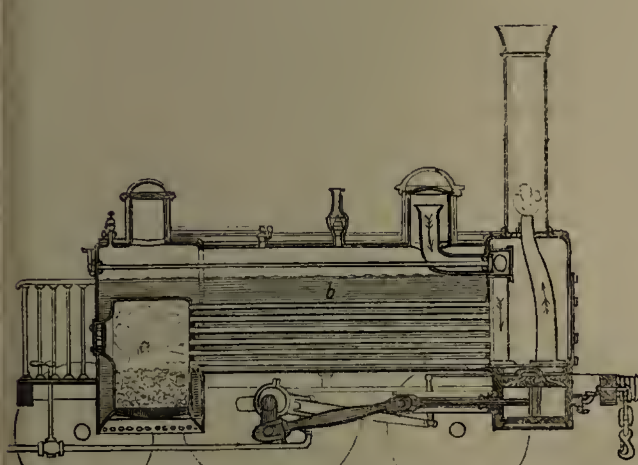
993.—Section of Railway Locomotive an Fire bo

990.—Euston Square Terminus, before the construction of the Hotels.

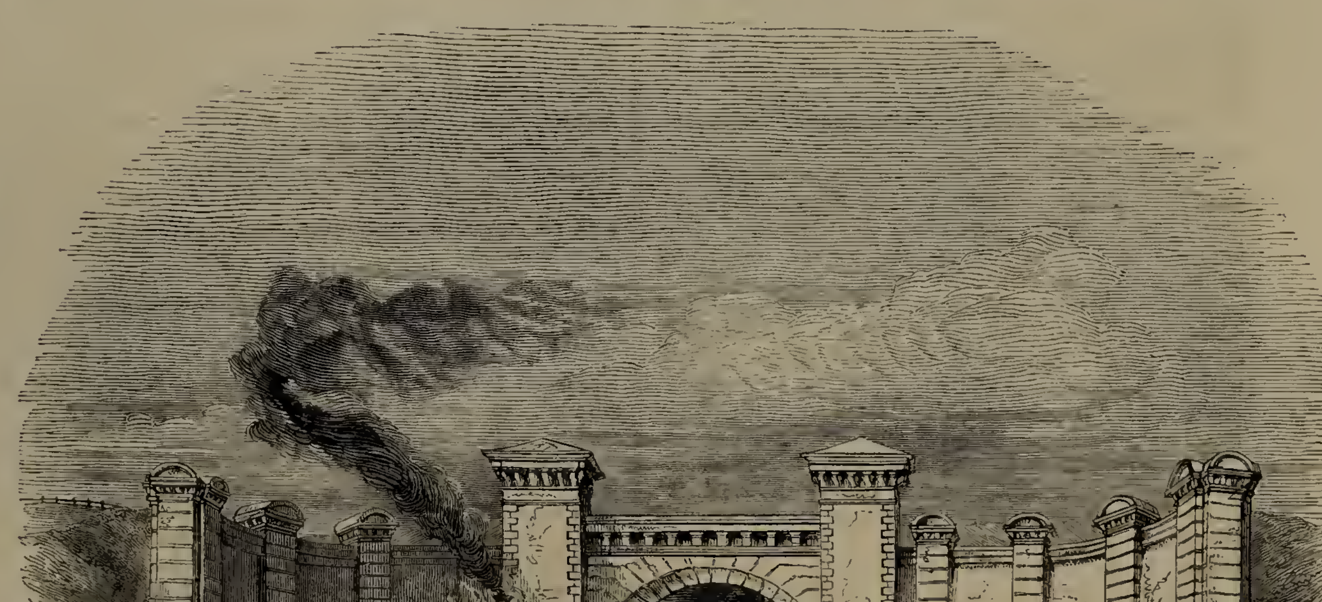


994.—Railway Locomotive.

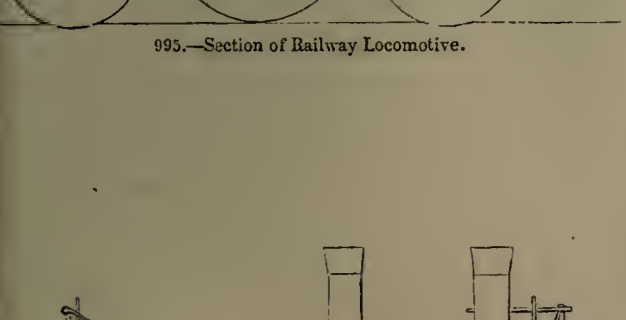
991.—Railway Terminus at Blackwall.



995.—Section of Railway Locomotive.



992.—Entrance to Primrose-Hill Tunnel.



996.—Railway Locomotive, side and end views.

provided with such tools as are used by the curriers, scrapes and rubs the leather in every part, so as to cause it to adhere closely and smoothly to the wood; first on the roof, and then on the sides, front, and back. The leather yields to the action of the tool in such a remarkable way, that all the creases gradually disappear, and the leather adapts itself to all the corners and angles without a single joint or seam of any kind. The leather is worked towards two central points, at the front and back, where the folds and wrinkles are gradually obliterated by rubbing and pressing. The edges are cut at the lines of junction with the lower parts of the carriage, and a brass or white metal beading is applied to hide the ragged edge of the joint.

The iron-work of a coach is not less important than the wood, since it includes the "springs" by which the body is usually shielded from concussion. Leather and wood are sometimes used for this purpose, in various ways; but steel-springs are employed in all good carriages. They are of various shapes, according to the kind of vehicle to which they are to be attached. Some are called "C-springs," some "S-springs," some "under-springs," some "elbow-springs," and so forth. The "regulating bow-spring" (Fig. 951) was invented by Mr. Adams for his new form of carriages. Most springs are made up of several plates of elastic steel, bent to the required form, laid one on another, and fastened by bands or rivets (Fig. 965) in such a way as to present the combined qualities of strength and elasticity.

The *wheels* of a carriage form a distinct branch of manufacture. In some, such as the "circular spring wheel" of Mr. Adams (Fig. 967), and the "horizontal guide-wheel" (Fig. 978), suggested by him for railways, a peculiarity of construction is exhibited; but in most cases they consist of spokes radiating from a central nave to a circular rim, and are made in the following manner:—The nave is a short block of elm, forming the middle of the wheel, and pierced with a hole to receive the axle-tree; it is turned to the desired dimensions and shape in a lathe, and is then placed in a kind of groove while the holes for the spokes are made; these holes are chiselled out, and it requires much accuracy of hand and eye to make them of the proper shape and size. The spokes are made of oak, and are fashioned entirely by a small cutting instrument called a "spoke-shave." When prepared, they are driven one by one (Fig. 969) into the holes of the nave, so as to radiate from it in all directions. The rim or edge of the wheel is formed of several segments of a circle, called felloes: these are composed of ash, and are, when shaped, fixed to each other end to end, and to the spokes by means of holes bored in each felloe. As a means of binding all these several pieces together, a hoop is put on in a singular manner. A strip of iron, of the proper width and thickness, is welded into the form of a hoop, somewhat smaller than the extreme circumference of the wheel; this hoop is heated red-hot, by which it expands to the size of the wheel, and it is then put over it, the wheel lying flat on the ground or on a supporting-plate. A number of men then assemble round the wheel (Fig. 950); and while one cools the red-hot iron by pouring cold water on it, the others beat the hoop with heavy hammers, by which it is made to cling very tightly to the wooden felloe. Iron pins are afterwards driven through the hoop or "tire" into each felloe of the wooden rim. The wheels for heavier vehicles are made in a similar manner, but with more attention to strength. Iron wheels have been introduced within the last few years, and partially used.

The painting of a coach is an operation requiring a good deal of care; for the beauty of appearance depends very much indeed on this process. The alternations of painting, smoothing, and varnishing occur much more frequently in this than in house-painting. The larger surfaces, such as the panels and doors, receive as many as ten or twelve distinct coatings of paint, each composed of the usual mineral colours, mixed with linseed-oil and turpentine; at intervals between these, the painted surface is rubbed with pumice-stone to remove all roughnesses and irregularities. When enough paint has been applied, the surface receives six or eight applications of copal-varnish, which, when dried, is polished to the utmost degree of brilliancy and smoothness, presenting to the eye nothing but a perfectly homogeneous surface.

The number of mechanical occupations connected directly or indirectly with coach-making is very great; for instance, there are coach-body makers, carriage-makers, coach-smiths, coach-platers, coach-beaders, coach-carvers, coach-trimmers, coach-lace makers, coach-lamp makers, harness-makers, coach-wheel-wrights, coach-painters, herald-painters—all of whom must apply their ingenuity before the gaily-decked coach can be transferred to its purchasers. We might also refer to the makers of spurs and of saddlers' ironmongery, to saddle-makers, and to whip-makers, as artisans whose industry bore indirectly on these matters. It is, however, worthy of remark, in this as in the case of pocket watches, that one class of manufacturers take the credit of being the makers of the whole. A "coach-maker," for instance, is considered to make the whole coach in his own factory; and a "watch-maker" is equally looked upon as the producer of the little world of mechanism within the silver or gold case. But in each case the party alluded to is a master tradesman, who receives from others the component parts of the manufacture, and causes them to be adjusted and put together under his own eye. It is true that more or less of the work is actually done on the premises of these manufacturers; but they are to be regarded rather as a medium for distributing employment to others. All that relates to the exercise of taste and elegance in the article to be manufactured depends mainly on these, aided by the taste of each person in the subordinate details of his own particular department.

By way of contrast to these details, we may give an amusing extract from Captain Lyon's 'Narrative of Travels in Northern Africa,' relating to a coach-making exploit in which he was engaged:—"I was consulted by Mukui (the Bey of Fezzan) respecting the construction of a coach; and I promised him that, if he could manage to procure good wood for the purpose, Belford should make it, and that I would train four horses to run it. I anticipated much pleasure and amusement in this new occupation, as I had at the time nothing to interest or divert me . . . . Belford now began to contrive the coach in question, and out of some old boxes, he made a body, six feet in length, three in breadth, and four in height. This he covered over like a higgler's cart, with an arched top, having a door behind, by which a person might easily get in; but Mukui finding that he could squeeze himself into a smaller compass, had it reduced in such a way as to render it necessary for him to be pushed in and shot out like a sack of coals. The body being completed, and springs being out of the question, it was mounted on two strong poles, which did duty as shafts; and to these were fixed two wheels from one of the field-pieces, so that the carriage stood at about three feet from the ground. The Sultan never for a moment quitted the place while Belford was at work, and was all delight at the progress which he made. Numbers of people came to see it, and many asked if that was the kind of vehicle in which our king and his wives used to ride. I was frequently puzzled how to answer; for, to say the truth, though Belford, considering his want of materials, had done wonders, it very much resembled one of those market-carts which are dragged about London by donkeys. It soon, however, lost that appearance, being covered by a splendid hood of scarlet cloth, and having a bed laid inside of it. The shafts, body, and wheels were painted green, though not very durably. The Sultan had some verdigris, which he had brought from Tripoli; part of this was mixed with olive oil, which, not drying, was scraped off; but the rest being prepared with vinegar formed a wash which answered his fondest expectations. The carriage was now as gaudy as the Sultan could wish, and he was the sole and happy possessor of it; but a serious inconvenience soon presented itself: the coach was not large enough to allow a place for the driver, and his horses were too spirited to be trusted alone with such a small state-carriage. After devising many plans to remedy the defect, we found we had but one expedient left, which was, to convert the vehicle into a gig. Accordingly a jack-of-all-trades, who was a very ingenious fellow, made, by my directions, a set of harness tolerably well, except that the little pad on the horse's back weighed above fifty pounds. This, however, was soon reduced; but when the animal was put into the shafts, we discovered that the carriage was so low as to form an angle of at least twenty-five degrees with the ground. The Sultan's head would consequently be about a foot lower than his feet; but as he intended, at any rate, sitting with his face to the horse, he thought nothing of this inconvenience."

THE RAILWAY SYSTEM, AS A MEANS OF TRAVELLING.

In almost every system of productive industry, there seems to be one particular time when improvement nearly reaches its commercial limit—not through the absence of ingenuity sufficient to advance it still farther, but through the general substitution of another system for it. Land-travelling seems to have arrived at some such point as this within the last dozen years. Who does not remember the admirable state to which the stage-coach system had arrived?—a state to which there was no parallel in any other country. Foreign tourists in England were universally struck with the excellent appointments of English coaches; the combined strength and elegance of the coaches themselves; the completeness of the harness; the high blood and admirable training of the horses; the mingled skill and fearlessness of the drivers; the punctuality in the time of starting; the rapid rate of movement; the cleanliness and order of the whole "turn-out"—all these points, in the long-stages which traversed our great main roads, had reached a state of excellence which, ten years ago, placed the English stage-coach system at the head of its class.

And yet where are these stage-coaches now? The sight of a "long stage" entering London has now an aspect of strangeness in it, and we look upon the coach as a thing of other days, an out-of-the-way creature that has lived beyond its time. One by one, during the last ten years, the great roads have lost their hives of coaches; the Birmingham, the Great Western, the Eastern Counties, the South-Western, the Brighton, the Dover—one after another these railways put a period to the existence of whole troops of stage-coaches: an extinction so complete, that one may sometimes marvel, seeing that after all these are merely commercial matters, how it could have been brought about. There was no lack of coaches, of horses, of drivers, of inns; and yet the system fell powerless when the railway system arose. Even while we are writing, an advertisement is going the round of the papers, announcing the sale of an entire stud of well-appointed stage-horses, whose services are rendered unnecessary by the recent opening of the Cambridge and Norwich line. The two great commercial elements of *time* and *money*—the former especially—are those to which we are to look for the cause of this mighty change; a cause so irresistible in its power as to bear down all before it.

Early Progress of the Railway System.

A railway is, in principle, nothing more than a smooth surface on which the wheels of a carriage may roll without much friction; for the mode of traction, by locomotives or otherwise, has no necessary connexion with the railway itself. When a horse draws a carriage over a gravel road, he has not only to pull the whole weight of the carriage, but has the extra work of dragging it over the innumerable little hills and hollows formed by the stones and the sinking of the gravel. If the road have a tramway or track of smooth stones for each wheel, like that which is laid down in the Commercial-road, the friction is greatly lessened, and the muscular power of the horse rendered much more effective. If, further, there were a guide or flange provided, of such a nature that the wheels could not shift about laterally, but were compelled to roll onwards in a direct course, a still greater efficiency would be obtained.

All these points must have attracted the attention of engineers and mechanical men ages ago, whether they put them in practice or not. Whatever minor attempts may have been made in this direction, there is proof that *rails* were used in the Northumberland collieries in the early half of the seventeenth century. These rails were pieces of wood laid down on the floors of the galleries or passages in coal-mines, to facilitate the transference of the corves or baskets of coals, and also along the roads by which the coals were conveyed to the ships at the river side. The wood forming the wheel-tracks was in pieces laid end to end, six or seven inches wide by five deep, and laid upon cross-sleepers or supports. The waggons in which the coals were conveyed, and which held from two to three tons of coals, had small wheels with flanges that overhung the inner edge of the wooden rail, and by that means they were kept in a regular course. Where the horse had to ascend an incline, a smooth iron plate was laid upon the rail, to lessen still more the friction at such a spot.

Such a contrivance as the above continued to be employed in the collieries for a century and a half; no circumstances having arisen to render its application necessary in ordinary travelling. In some places stone trackways were used instead of wood; and in others iron was laid on the wood; but wood alone continued in use generally until the substitution of rails made wholly of iron. It was about the year 1780 that cast-iron rails were used, having a projecting edge or flange to keep the wheels in their right place. Some few years afterwards the plan was adopted of supporting the rails on square blocks of stone placed at intervals along the road, instead of wooden sleepers. Next ensued the invention of *edge*-rails, that is, such as present only a very narrow surface for the wheels to rest on, and requiring that the wheels should be provided with some kind of flange to prevent them from running off the rails. This plan was adopted about the beginning of the present century; and the wheels at first used with it had grooved or concave tires, whose hollow worked into the upper rounded edge of the rail. These edge-rails, under one or other of several different forms, were found so advantageous that they were adopted in nearly all the collieries in England. Down to the year 1830, most or all of the rails employed were made of cast-iron; but as this material was very brittle and fragile, frequent repairings and adjustments were rendered necessary. But about the period just named, the plan was commenced of rolling bar iron between cylinders so formed as to give the proper shape for rails, and from that moment a feature of great value was imparted to the subject.

The railways hitherto spoken of were connected exclusively with the coal-mining districts; and their introduction into other quarters was a very gradual matter, until within the last fifteen years. A railway-track for the conveyance of coal to Leeds was the subject of a private act of parliament, in 1758; and after that railways to a limited extent were allowed in connexion with certain canals. But the first railway for

general public use was the "Surrey Iron Railway," for which an act was obtained in 1801, and which was proposed to be taken by the Brighton Company in the recent session of parliament to afford them an access to a west-end terminus. During the next twenty years about twenty similar contrivances were brought forward; and then succeeded that which, in many respects, may be regarded as the mother of British railways, as we now understand them, viz. the Stockton and Darlington. The extent of the plan; the distance that coals would have to be brought by this railway to the port of Stockton; the opposition which the scheme met with and over which it finally triumphed; the engineering difficulties of the line; the large outlay connected with, and the immense traffic which shortly came upon it—all gave to this line an importance which attracted the eyes of engineers and commercial men towards it. The question at once arose—if such a line can carry coals and merchandise quickly and cheaply, why should it not also convey passengers?

A successful answer to this question was first given by the Liverpool and Manchester Railway. There are no other two towns in the kingdom between which the commercial intercourse is so close and so vast as these two. Roads and canals, though improved to the highest degree, became unequal to the efficient transit of goods from the one place to the other; and in the year 1824 the merchants of Liverpool took steps for the formation of a railway. A company was formed, the capital subscribed, and an application to parliament made. There was, however, a strong opposition to the bill in 1825; and the company did not succeed in obtaining their act till the following year. It is curious, at this distance of time, to look back at the kind of evidence given before those parliamentary committees. One of those formidable difficulties which the engineer, George Stephenson, had to contend against was the Chat Moss, a large bog, comprising an area of twelve square miles, so soft as to yield to the pressure of the foot, and in some parts so fluid that a piece of iron would sink to the bottom by its own weight. The depth of this soft and yielding mass varied from ten to thirty-five feet, beneath which is a bottom of sand and clay. Over this moss the railway had to be carried, and few men shared in the confidence with which Mr. Stephenson viewed the matter. The following questions and answers occurred before the parliamentary committee on the bill, the witness being a civil engineer of some eminence:—"Tell us whether, in your judgment, a railroad can be safely made over Chat Moss, without going to the bottom of the bog?" "I say, certainly not."—"Will it be necessary, therefore, in making a permanent railroad, to take out the whole of the moss to the bottom, along the whole line of road?" "Undoubtedly."—"Will that make it necessary to cut down the thirty-three or thirty-four feet of which you have been speaking?" "Yes."—"And afterwards to fill it up with other soil?" "To such a height as the railway is to be carried; other soil mixed with a portion of the moss."—"But suppose they were to work upon this stuff, could they get their carriages to the place?" "No carriage can stand on the moss short of the bottom."—"What would they do to make it stand,—laying planks or something of that sort?" "Nothing could support it."

The event falsified all these predictions. The railway *was* laid upon the moss, and has continued to be an efficient support for the rails. The difficulties were, however, very great. At one part of the moss, for a length of about a mile and a half, an embankment had to be carried twenty feet above the level of the surface; the earth used for this purpose pressed down the soft bog-soil beneath it; and many thousand cubic yards gradually and silently disappeared before the whole body of material became sufficiently consolidated to maintain the required position. When a firm bottom was thus obtained, hurdles of brushwood and heath were placed on the soil, wooden sleepers were placed upon these, and the permanent way fixed above the sleepers. In point of fact, the whole superincumbent structure may be said to float on the surface of the bog beneath.

Many other heavy and difficult works had to be executed. The railway had to be carried to the docks and waterside at Liverpool by means of a tunnel under the entire town: this tunnel is more than two thousand yards long, twenty-two feet wide, and sixteen high; the greater part of it being on an incline of one in forty-eight, giving a descent of a hundred and twenty-three feet. Another tunnel was required to give an outlet to the passenger station in the centre of Liverpool. At a little distance from Liverpool the line had to be cut through a steep eminence called the Olive Mount; this gave necessity for the making of a cutting, two miles long and in some parts seventy feet deep, out of hard rock; the narrow ravine being bounded on both sides by perpendicular walls of unhewn rock. Beyond the Olive Mount occurs the great Roby embankment, three miles long, varying in height from fifteen to forty-five feet, and in breadth at the base from sixty to a hundred and thirty-five feet; the quantity of earth and stone required for this embankment was more than half a million cubic yards. The Rainhill level, produced by excavating two hundred thousand cubic yards of earth, next extends two miles. The Parr Moss, smaller in surface than the Chat Moss, but more liquid in consistence, then occurs; and a little beyond this is the beautiful Sankey Viaduct, by which the railway is carried, on a series of nine arches, over a valley sixty or seventy feet beneath. To show the nature of the ground that the engineer had to contend against, it will suffice to state that each of the brick piers of the viaduct is supported by two hundred oak piles, driven hard into the earth for a distance of twenty or thirty feet! At Kenyon is a cutting from whence eight hundred thousand cubic yards were excavated. At a short distance beyond this is the Chat Moss, which was made to bear the weight of many tons where before a foot could hardly tread in safety.

All these are matters of engineering which, in our own day, are taken as things of course, and excite no especial attention. But in 1830, at which date they were brought to a conclusion, they were deservedly ranked as marvellous specimens of skill, since the engineer had to depend on his own resources for the means of extrication from the numerous embarrassments which occurred: there was no joint-stock fund of experience to which he might appeal—or at least a very slender fund; and it is not to be wondered at that the expense very far exceeded what the engineer and the company had anticipated.

It was on the 15th of September, 1830, that the eventful opening was made, by which conclusive evidence was afforded to the country of the practicability and efficiency of railway-transit. Eight locomotive engines, made by Messrs. Stephenson, at Newcastle, started on that day in succession, drawing twenty-eight carriages, capable of containing a party of about six hundred persons. The matter was made as much as possible a matter of rejoicing; but a damp was thrown over the events of the day by the death of Mr. Huskisson, through an unhappy accident which occurred. On the following day, one of the engines drew a hundred and thirty passengers from Liverpool to Manchester in an hour and fifty minutes; in the evening it returned with twenty-one passengers and three tons of luggage, in one hour and forty-eight minutes; and on Friday the 17th of September, the trains commenced running regularly for traffic; the time allowed for the journey (thirty-one miles) being rather under two hours. The commencement of the merchandise traffic was on the 4th of December, in the same year; on which day the "Planet" locomotive engine drew eighteen waggons, containing two hundred barrels of flour, thirty-four sacks of malt, sixty-three bags of oatmeal, and a hundred and thirty-five bags and bales of cotton. (It is worth while recording these items, as marking the commencement of a new commercial era.) The gross weight drawn, including the waggons and engine-tender, was about eighty tons; the speed over level ground was about twelve or fourteen miles an hour; an assistant engine helped the train up the inclines; and the whole journey was performed in rather less than three hours. Two months afterwards, a gross weight of a hundred and sixty-four tons was drawn from Liverpool to Manchester, at the average rate of twenty miles an hour over the level part of the line. This was naturally looked upon as a great achievement.

It need excite but little wonder that a system so marvellously successful in an engineering point of view should have excited the attention of other towns, other engineers, and other companies. A mistaken estimate was in the first instance made as to the kind of traffic which would pay the shareholders; for it was at first supposed that goods traffic would pay better than passenger traffic. This has been fully disproved by the result. For instance, if we take from any of the Railway Journals an abstract of the traffic on thirty-four railways for the last week in July of the present year (1845), we find that, out of a gross receipt of about 160,000*l.*, the sum received from passengers is about 120,000*l.*, or three-fourths of the whole; leaving 40,000*l.* as the merchandise receipt. Still this misconception did not involve any very serious evils; for if the merchandise traffic fell short of expectation, the passenger traffic soon reached a height which no one had dreamed of before.

One by one, new companies started into existence, until the surface of the country became intersected with lines in all directions. Every county, with the exception of Lincoln, Cornwall, Hereford, and a few others, now exhibits (and all will soon exhibit) specimens of engineering art such as those of which a few specimens are here given. In Figs. 970, 971, 980, 981, we have the Moorish Arch, the Olive Mount Cutting, the Edge Hill Tunnel, and the Sankey Viaduct, of the Liverpool and Manchester Railway. In Figs. 990, 992, 997, 998, there are shown the London Terminus, the Primrose Hill Tunnel, the Birmingham Terminus, and the Avon Viaduct, of the London and Birmingham Railway. In Fig. 982 is a curious specimen of engineering on the West London Railway, near Kensal Green, where a canal goes over the railway, and a coach-road over the canal at one spot. In Fig. 991 is the water-side Terminus of the Blackwall Railway; in Fig. 1000, that of the four railways which come up to London Bridge; in Fig. 1002, the bold and astonishing "Abbot's Cliff Tunnel" of the Dover Railway; and in Fig. 1003, part of the viaduct of the Greenwich Railway. It may be well to remark that some of these cuts represent the railways or stations as they were a few years ago, slight alterations or additions having been subsequently made.

We shall, further on, give a few details as to the actual state of the railway system; but it may be well first to glance at the

Materials and Construction of Railways.

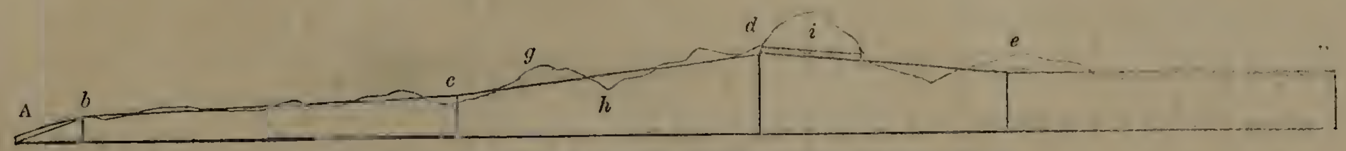
When an engineer is about to plan the construction of a railway, he has to consider, not only the commercial importance of the towns to which or near which he passes, but also the levels and general character of the country. The use of smooth iron rails would be of little value if they merely followed the contour of the country over hill and dale; the rails must be either laid upon a level, or upon inclines having a very gentle slope. If the country does not present these levels or gentle slopes naturally, they must be produced artificially; and hence arise the great works which distinguish our railways. The tunnels, cuttings, viaducts, and embankments—all are for the most part intended to produce a line more nearly level than the surface of the country presents. In the tunnels and cuttings material is removed; in the viaducts and embankments material is added; and it is a great point with the engineer to avoid either embankments alone or cuttings alone; but to adopt such a combination of the two that the earth or other material removed from all the cuttings and tunnels may be about equal in quantity to that required for the embankments.

We may take Fig. 999 as a means of showing how an engineer proceeds. Let A be a sea-port and F an inland town, to which a railway is about to be carried; at *i* is a lofty hill, or range of hills much higher than any other part of the country on the line; and from thence to either terminus there are many alternations of hill and valley; moreover, the town at F is on a much higher level than the sea-port at A; the question then arises, how to surmount all these variations of country, and in what proportions to make use of tunnels, viaducts, cuttings, and embankments. The undulating line in the woodcut represents the surface of the country, and the longitudinal line at the bottom represents the base or datum line from which all the elevations are measured. By a cutting from A to *b*, a straight line is attained, which we may suppose to be as steep as prudence will admit (the angles in the cut are purposely made far more steep than they are in practice, to show the object more clearly). Another incline, not so steep as the former, is made from *b* to *c* by a series of cuttings and embankments. A steeper incline succeeds, from *c* to *d*, by means of deeper cuttings and loftier embankments than the former; or it may be that the valley *h*, separated from that at *c* by the hill *g*, is crossed by a viaduct instead of by an embankment. Arrived at *d*, the engineer finds that the hill *i* is too lofty to be passed by an open cutting, and he therefore pierces a tunnel through it; this tunnel is made part of an incline from *d* to *e*, the remainder of the incline being completed by embankments and cuttings. The rest of the line, from *e* to the terminus at F, admits of being made by a series of light cuttings and embankments, so as to bring the trains down to the terminus by an easy slope. This is, of course, an imaginary instance; but it will serve to convey an idea of the matter under consideration.

In the formation of embankments, which consist generally of earth, the sides have a slope given to them, varying according to the nature of the material. It is a part of the engineer's business to discover what degree of slope will give permanence to the embankment, for each kind of material, to avoid the "slips" which have sometimes so perplexed railway companies.

In tunnelling, the excavation of the material, whether stone or earth, is a species of mining, conducted with the pick and other mechanical tools, aided sometimes by gunpowder. If the tunnel be made through hard rock, the roof and sides will maintain their position without any other support; but through soft soil an arching of brickwork is requisite. Viaducts and bridges are results of the same kind of skill, whether engineering or mechanical, as is shown in other instances. In open cuttings the sides or walls are very rarely vertical; for it seldom happens that the material is hard enough to remain secure if cut down vertically. The sides are nearly always made sloping, the slope increasing according as the material is looser or softer. Hard rock will allow of a vertical side to the cutting; chalk requires a slope of 45°, or one foot horizontal to one vertical; gravel requires a slope of three feet to two; and some of the softer kind of clayey soil require a slope of four horizontal to one vertical. One considerable item of expense, where a railway goes through a deep cutting in a soft soil, is the large quantity of land required to be bought up, since the horizontal spread of the sloping sides takes up many times the width of the railway itself. The same may

1001.—Locomotive-Engine Factory.



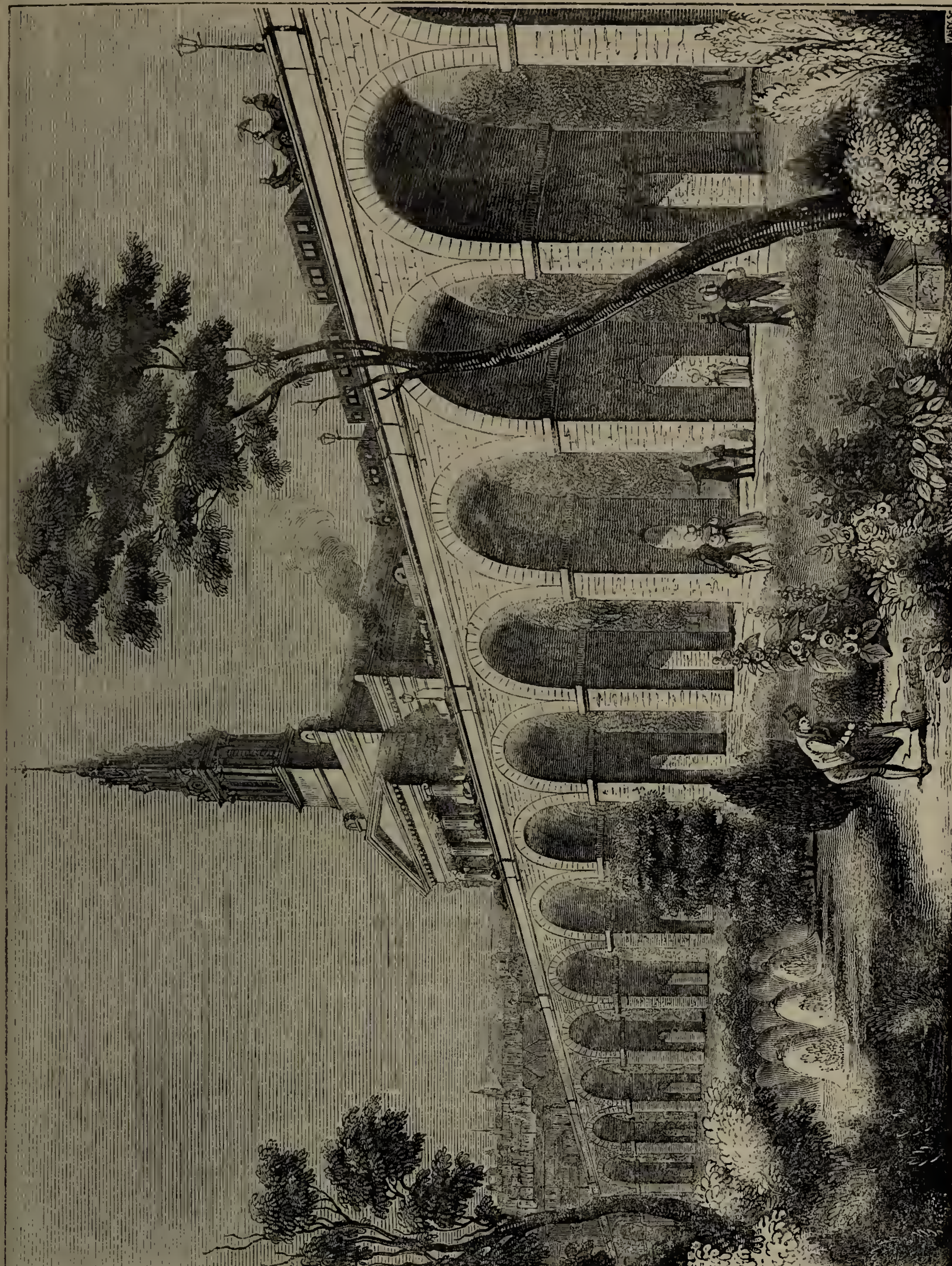
999.—Section, showing the nature and object of Railway Cuttings and Embankments.

1000.—London-Bridge Terminus of the South-Eastern, Greenwich, Brighton, and Croydon Railways.

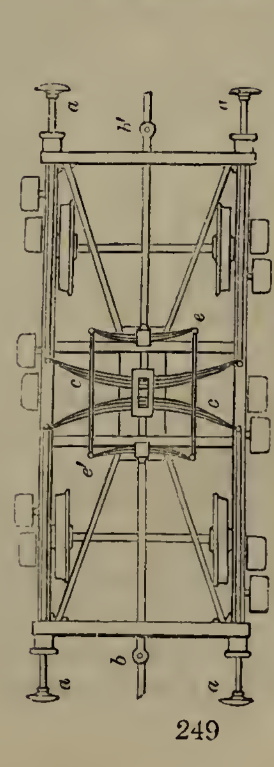
997.—Birmingham Terminus as at first made : London and Birmingham Railway.

998.—Avon Viaduct, London and Birmingham Railway.

1002.—Abbot's Cliff Tunnel, Dover Railway.

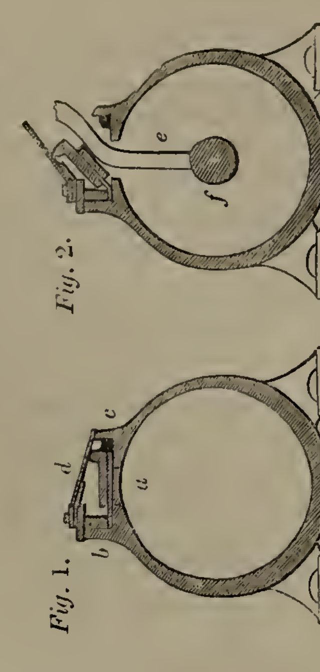


1003.—London and Greenwich Railway.



1004.—Plan of Railway-carriage Framework.

1005.—Railway Engine and Carriages, in the form first used on the Liverpool line.



1006.—Atmospheric Railway Tube.

be said of a lofty embankment, which requires a very wide base to secure the permanence of the earth above.

Some of our great railways exhibit extraordinary examples of these heavy works. On the Dover line, for instance, the seven miles comprised between Folkestone and Dover are beset with difficulties of the most extraordinary character, entailing an expenditure of something like half a million of money to surmount them. At Folkestone the line crosses a valley by a viaduct a hundred feet in height; and from thence to Dover the engineer had to battle against sea-cliffs for the whole of the distance. First there is a short tunnel, called the "Martello Tunnel;" beyond which commences the "Warren Cutting," two miles in length. Then we come to the "Abbot's Cliff Tunnel," which passes, for the length of a mile, under chalk cliffs of great elevation; on the eastern face of which the line emerges at an elevation of about sixty feet. For about a mile further, the railway is supported by a sea-wall or "revêtement," formed on the face of the cliffs, which rise steeply to a great height on the one side; while the other, protected only by a parapet-wall, is open to the sea. It was at this part of the line that the gigantic explosions by galvanic power were made two or three years ago, as a means of removing large masses of rock which interfered with the straight direction of the sea-wall. The sea-wall ends eastward at the "Shakspere Cliff," where a double tunnel is pierced from end to end; one tunnel being appropriated to the down-train and the other to the up. Beyond this tunnel, a timber viaduct carries the line along the sea-beach, in front of the cliffs, to Archcliff Fort; and a tunnel through the rock on which this fort is situated carries the line close to Dover Harbour. This detail will afford some idea of the vast works which our engineers are not afraid to plan, and our shareholders not afraid to pay for.

The "permanent way" of a railway is the level road prepared for the reception of the rails, after the completion of the heavy works, such as viaducts, embankments, tunnels, cuttings, bridges, &c. When all the works are brought to "formation level," as it is called, that is, the whole surface brought to the proper levels and inclines, a "ballasting" of broken stone is laid all over, to the depth of a foot or more; and when this is completed, the supports for the rails are laid down. A singular diversity has been shown in the mode of giving this support. In the wooden railways before alluded to, this was comparatively an easy matter; for the rails were made of the same kind of material as the sleepers which supported them. But when iron rails began to be used, the choice of supports for them became an important matter. One method has been to place solid stone blocks imbedded in the ballast, at intervals of a few feet apart; to fix iron supports or "chairs" to these blocks, by spiking them down into the stone; and to fix the rails to the chairs. This plan is liable to inconvenience; for the points of support for the rails and chairs being isolated one from another, are liable to be deranged by subsidence of the ground, by the vibration consequent upon the passage of heavy trains, and by other causes. The blocks employed for these purposes are generally about two feet square by one thick, roughly squared, but made even at the surface to receive the chairs. Sometimes they are placed rectangularly and sometimes diagonally, with respect to the direction of the road. Holes are made in them to receive the spikes by which the chairs are fastened; or rather the holes receive wooden plugs, and the plugs afford a hold for the iron spikes.

As a substitute for blocks, cross sleepers are sometimes used; that is, long pieces of timber laid across the line, so that both lines of rail may, at a given spot, be bolted to the same sleeper, thereby preserving the parallelism.

The shape of the rail, and the mode of fastening to be adopted, has undergone more discussion than almost any other matter in connexion with railways. Whether the rails should be straight and regular in every part, or whether they should be strengthened at certain places between the joints, is one of the questions for discussion. In Fig. 979 we may see how many different forms have been given to the rails, and to the chairs by which they are supported. In the progress of railways, it was gradually found that the rails at first provided were not heavy enough for the work required of them, since they yielded or oscillated between the points of support. On the best lines the rails now used weigh from sixty to eighty pounds the yard. They are made of wrought-iron; but the chairs by which they are supported are made of cast-iron.

The "continuous bearings" for the rails now adopted on some railways, are two parallel lines of timbers, extending end to end in the direction of the railway, and each line supporting one line of rails. These were first used in the American railways, on account of the cheapness of timber in that country. Mr. Brunel was the first engineer who employed the method on anything like an extensive scale in England; he advocated it under the expectation that the railroad would be smoother and more elastic than when stone blocks were used, and would on that account be more agreeable to ride upon, cheaper to maintain, and safer for travelling at high velocities. Although some of these expectations may not have been realised, the continuous timber bearings are now regarded very favourably, and have not only been used on the Great Western, London and Croydon, and other lines, but the stone-block supports formerly used at the London and Greenwich and the Dublin and Kingstown have been removed to make way for the continuous bearings. These bearings enable the engineer to dispense with the use of chairs, since the rails are at once screwed down to the timbers themselves. In Figs. 972, 973, 974, 975, 976, 977, 979, 983, 984, are various illustrations of the matters alluded to above: such as the old timber rails, the stone blocks, the transverse sleepers, the rails and chairs for the block system, the rails for the continuous bearer system, &c.

A very nice feature in the laying down of a railway is the management of the "switches" and "points" by which a train is enabled to go from one line of rail to another. Diagonal bars of iron, placed at their ends near, but not in contact with, the rails; and levers to move them to and fro,—form the chief means of effecting this crossing. In Figs. 985, 986, 987 we see different examples of the way of effecting this; the arrows show the different movements, either of the levers which move the switches, or of the trains from one line to another. Sometimes a railway engine or carriage, detached from the rest of the train, is turned round in position, either at right angles or to a complete reversal, by means of the "turn-table" (Fig. 989). This contrivance consists of a circular table or platform of iron, on a level with the ground of the railway, and capable of revolving on a central axis by means of small friction-wheels working beneath it. The purpose of such a turn-table is to transfer a locomotive or a carriage from one line of rails to another. Suppose the carriage required to be shifted from the lower to the upper line marked in the cut, it would in that case be wheeled upon the turn-table; the turn-table would be made to revolve 90°, or a quarter of a circle; the carriage would be wheeled along the cross track to the other turn-table; this would similarly be made to revolve 90°; and the carriage would then be in a proper position to wheel along the upper line of rails.

A very important feature has arisen in respect to the width at which the rails are placed apart, or, as it is technically termed, the "*gauge*." A difficulty has occurred which was not contemplated in the early history of the railway system, how to ensure uniformity of gauge in all railways, or how to avoid inconvenience where this uniformity does not exist. So far as the principle involved is concerned, almost any width would do, be it three feet or ten feet, provided the carriages and other arrangements were made in conformity thereto; but practically the limits have been confined between four feet eight inches as a minimum, and seven feet as a maximum. Many of the colliery railways have a gauge of four feet; but those in the best mines are four feet eight inches and a half. The Stockton and Darlington line, being a sort of link between the colliery and the passenger railways, had that gauge; and this accidental circumstance (for there seems to be no peculiar merit in this exact number of inches and half inches) led to what may be pretty correctly called the national gauge. The Liverpool and Manchester, the London and Birmingham, the Grand Junction, the Manchester and Leeds, the Midland, the South Western, and nearly all the great lines adopted the same guage, principally for the convenience of one line joining another without requiring a change of carriages. The Blackwall line adopted five feet; so did the Eastern Counties, but this was afterwards altered to the narrower gauge; two or three small railways in Scotland have a gauge of five feet six inches; six feet two inches and five feet three inches are two gauges employed in the north of Ireland; and the Great Western system of Mr. Brunel has a gauge of seven feet. It is this latter which now forms the subject of so much discussion, and which at the present time (August, 1845) is engaging the attention of a government commission. By the railways either formed or sanctioned, the broad and narrow gauges will meet at Dorchester, Salisbury, Basingstoke, Rugby, Worcester, Cheltenham, Gloucester, and Wolverhampton: at all of these points an inconvenience of greater or lesser amount will occur from the diversity of gauge; and it is with the hope of devising a remedy for the mischief that the "Commission on the gauges" has been appointed.

The Modes of Traction on Railways.

Supposing a railway to be formed, and all the stations and other arrangements of a like kind determined on, the next point is—the mode of drawing or propelling the carriages along the railway. This is perhaps the most wonder-working feature in the railway system, since it has developed to such an extraordinary degree the power of steam.

So long as railways were confined to colliery districts great speed was not sought for, and the means of traction were comparatively simple. It was often so arranged that the line along which coals were conveyed to a ship, staith, or other depôt, should descend at such an angle that the impetus of a loaded train descending should be near about balanced by that of an empty train of trunks ascending; so that very little more would be necessary than to give the laden train a start from the top of the slope, and let it find its way downwards: a continuous rope being so attached as to draw up an empty train on the other line of rails, as fast as the laden train descended. Another mode was by means of stationary steam-engines, which drew the waggons by means of ropes guided by pulleys or sheaves in the centre of the track between the rails; this mode was adopted when the coals or other cargo had to be drawn up an incline. Where there was neither an ascent nor a descent, the trucks were generally drawn by horses. These three methods may be spoken of not only as practised, in the early history of the railway system, but as being still extensively followed in various mining districts.

The mighty locomotive was, however, destined to work a great revolution in these matters. As early as the year 1784 the genius of Watt suggested that the power of steam might be brought into useful requisition in locomotion; but nothing positive seems to have been done until the commencement of the present century, when Messrs. Trevethick and Vivian, Cornish engineers, patented a high-pressure engine which was suitable for locomotive purposes. In 1805 they used, on the Merthyr Tydvil tramroad, an engine such as that represented in Fig. 996, in which great ingenuity was bestowed in the arrangement of the several parts for the attainment of the object in view. The engine drew a train of waggons containing ten tons of iron and a considerable number of persons at the rate of ten miles an hour. The talented engineer, Trevethick, afterwards turned his attention to other matters, and the locomotive, as applied to railways, made little progress; but the germ was formed which afterwards ripened into importance.

For many years an imaginary difficulty retarded the progress of this great system. There was a prevalent opinion that smooth iron rails would be so unfavourable to the proper action of the wheels of the locomotive, that on a slight ascent they would slip round without advancing. Hence the application of the locomotive to common roads was more attended to than on railways. About the year 1770 an engineer in France is said to have constructed a steam-engine on wheels, which had the power of locomotion to a certain degree. Then came the suggestion from Watt, before alluded to; then a model by Mr. Murdoch, an ingenious gentleman of Cornwall; and then the talented invention of Trevethick and Vivian. Mr. Symington in Scotland, and Mr. Evans in America, also produced models of steam-engines adapted more or less for locomotive purposes. All these schemes, for some cause or other, were laid aside for many years; but about the year 1820 a new feeling arose in favour of steam locomotion on common roads. Mr. Griffith obtained a patent for a road-locomotive in 1821; and this was followed by a number of curious inventions, in one of which the locomotive was made to walk along the road on six iron legs, very like a spider; while in another the engine was contained in a kind of enormous drum, which it caused to revolve on the same principle that a squirrel sets his cage in motion. From the year 1824 onwards, the names of at least twenty persons are recorded as having contrived locomotive engines capable of working on common roads. Gurney, Hancock, Church, Maceroni, Squire, Anderson—all are names connected with this department of mechanical ingenuity; and a reader of ordinary industry can hardly fail to have met with narratives of the performances of the engines produced. Several of these have been capable of maintaining an average speed of ten or twelve miles an hour for considerable distances, and a much higher speed for short distances.

But whatever success may, in a mechanical or engineering sense, have attended these carriages, they have all failed in a commercial point of view; and without hazarding any prediction as to their future history, we may at once proceed to the application of the locomotive to railways instead of to common roads. The apprehensions of engineers as to the liability of the wheels to slip round on smooth iron rails, led them to adopt many curious contrivances to make the two surfaces bite or cling better together. Sometimes the rim of the wheels was notched or grooved; sometimes the wheels were made with cogs, which worked in the teeth of a rack, laid down on the railway; sometimes the progressive motion was sought to be aided by passing a rope or chain round a grooved wheel turned by the steam-engine; in one instance the engine had two iron legs attached behind, which *walked* up hill as a means of assisting the wheels. But all of these gave way by degrees; since it was found that the inventors had been battling against a phantom of their own creation. The wheels do *not* slip round in the way that was anticipated; and the cumbrous additions here alluded to were thus rendered unnecessary. So little was the power of the locomotive known, that when the Liverpool and Manchester Railway was approaching completion, it had not yet been determined what mode of traction should be adopted: whether horses, sta-

tionary engines, or locomotives. The directors were open to suggestion; and suggestions poured in upon them from all quarters. A writer at the time thus amusingly speaks of the extravagant schemes proposed:—"Hydrogen gas and high-pressure steam; columns of water and columns of mercury; a hundred atmospheres and a perfect vacuum; machines working in a circle, without fire or steam, generating power at one end of the process, and giving it out at the other; carriages that conveyed every one its own railway; wheels within wheels, to multiply speed without diminishing power—with every complication of balancing and counteracting forces, to the *ne plus ultra* of perpetual motion. Every scheme which the restless ingenuity or prolific imagination of man could devise was liberally offered to the company."

The directors caused an exact inquiry to be made into the power of the locomotives employed up to that time on some of the colliery railways; and the result was, a decision that the locomotive mode of traction should be the one adopted. The next point was, the obtaining of the best form of engine that skill could devise; and for this object the directors offered a handsome premium to the inventors of the engine which should best go through a particular ordeal on a given day. The prize was a sum of five hundred guineas; and the conditions of the trial were—that the engine should produce no smoke; that the pressure of the steam should be limited to fifty pounds on the square inch; that the engine should draw at least three times its own weight; that it should be supported on springs, and not exceed the height of fifteen feet. In accordance with these terms, three engines were prepared to contest for the prize on a given day in October: viz. the "Rocket," constructed by Mr. Stephenson; the "Sansparcil," by Mr. Hackworth; and the "Novelty," by Messrs. Braithwaite and Ericson. A line of railway was chosen for the trial, on a level piece of road about ten miles in length, near Rain-hill: the distance between the two stations was a mile and a half; and each engine was required to travel this distance backward and forward ten times, thus making the journey thirty miles. The "Rocket," which proved to be the successful engine, performed this journey twice; the first time within two hours and a quarter, and the second time within two hours and seven minutes: its speed varied at different parts of the journey; the swiftest motion being rather above twenty-nine miles an hour, and the slowest about eleven and a half. The other two engines became more or less disabled during the contest; and the "Rocket" bore off the prize in triumph. Every railway (with some rare exceptions under peculiar circumstances) has since adopted the locomotive system; and the factories where these beautiful specimens of mechanical ingenuity are made are now among the finest and largest of engineering establishments (Fig. 1001).

In all locomotives the steam from the boiler is admitted into cylinders in such a way as to drive pistons to and fro within the cylinders; and the rods of these pistons, being thus affected by a reciprocating movement, are made to impart this action to the rotation of the wheels. But the modes of transferring these effects have been very various. In Trevethick's engine (Fig. 996), the piston worked vertically in the cylinder, and the piston rod was connected with a lever whose lower end acted on the hind wheel of the carriage. In Fig. 993 the chief part of the cut shows a longitudinal section of a kind of locomotive, in which the cylinder is placed diagonally, and the piston rod is connected by a lever with one of the spokes of the wheel. In Fig. 994 we have an exterior view, and in Fig. 995 a longitudinal section, of one of the six-wheel locomotives now in use on the principal railways. There is at the back a fire-box, in which heat is kindled sufficient to make the water boil, which is contained in the long cylindrical boiler. The smoke and heated air pass through a number of tubes immersed in the water, whereby the water is speedily brought to a boiling temperature. The steam given off from it ascends to the top of a kind of dome, and then descends a pipe which conveys it to the cylinders, one on either side of the front of the engine. The steam drives the piston, first in one direction and then in the opposite one; and the rod of the piston has thus an alternating motion which is made to act upon the wheels.

The number of wheels to a locomotive, whether four or six, the diameter and length of the cylinders, and the general details of arrangement, are now matters of anxious inquiry among engineers, since the attainment of high speed is now regarded as a desideratum in all quarters. Twenty miles an hour is a rate looked upon as belonging to other days, and even that of thirty is falling into the shade. Forty, fifty, nay, sixty miles an hour are in the present day regarded as matters within the daily observation of travellers. It would be altogether premature to venture on a conjecture as to the speed likely to be ultimately attained by the locomotive.

The carriages on a railway are now sufficiently known to most persons to need but little description. The trains first used on the Liverpool and Manchester Railway presented some such appearance as that sketched in Fig. 1005; the engine having four wheels and a lofty funnel or chimney, and the carriages being mostly those designated "first class;" for it had not then been learned that the second and third class passengers are commercially the most important. Fig. 988 shows one of the modes in which Adams proposed to adapt his "equirotal" system of carriage wheels: by having each carriage pivoted to those before and behind it in the way shown, he supposes the train to possess a much greater facility of turning than it has under the ordinary construction. In Fig. 1004 there is a horizontal plan of the under framework of a common railway carriage: *a a* are the "buffers" or elastic stops which check the concussion of one carriage against another, and which are kept in position by the springs *c c*; *b b* is the traction bar, by which one carriage is connected with those behind and before it, which has an elasticity of action given to it by the springs *e e*; the oblong square appendages on the outside of the framework are the steps by which passengers ascend into it.

The "*atmospheric*" system of traction is one which is likely in a very few months to be put decisively to the test. It is at the present time, and has been for a year or two past, in active operation on the Kingstown and Dalkey Railway near Dublin, where it has succeeded admirably. But that line is less than two miles in length, and does not afford the means for solving numerous important questions which must arise on a long line of railway. The principle of a stationary engine acting on a railway has hitherto been most extensively developed on the Blackwall line, where a rope four miles long, by being made to wind round a large wheel near a stationary steam-engine, is made to pull along the carriages containing the passengers; the carriages being hooked on to the rope, and the stoppages at various intermediate stations being made by loosening a carriage from the rope at each station. But if the line were too long for one rope to work it, there would be a difficulty at the point where two ropes might meet in the middle of the line. Such a difficulty may also occur on the atmospheric principle; and it will not be until the opening of the Croydon Atmospheric Railway that means will be furnished for estimating the means employed.

In the atmospheric system there is a tube fifteen or eighteen inches in diameter laid down on the railway from end to end, midway between the two rails of each track. At intervals of about three miles along the line an engine-house is erected, containing either one or two powerful steam-engines, the action of which is to pump out the air from each three-mile section of tube. The carriages pass over the tube, and are attached to one front carriage, or rather machine, which is connected with a piston within the tube. When the air is exhausted from the tube in front of the piston, the latter is propelled onward by the air behind it; and a connecting vertical rod, sliding in a groove in the upper part of the tube, communicates this onward movement to the carriages above. The management of this groove is one of the most difficult features of the system, since it is necessary to provide against leakage. In Fig. 1006 the left-hand figure represents a section of the tube when the slit is closed; and the right-hand one where it is open for the passage of the bar: *a* is the slit; and between *b* and *c* is the cell or recess for receiving the valve *d*. In the right-hand figure, *f* is the central point of the piston, and *e* the bar or rod which connects the piston with the carriage above. It will here be seen in what way the valve is opened to admit the passage of the bar; but it would require a much more intricate figure to show the ingenious means adopted for preventing leakage of air from the tube.

At present (August, 1845) the atmospheric projects are thus circumstanced:—The Croydon Company are empowered to lay down an atmospheric line by the side of their present line, along the whole distance from London Bridge to Croydon. They have also obtained an Extension Act to Epsom, intended to be worked on the same system. The heavy works are in progress on both lines, but will not be brought to completion till the efficiency of the atmospheric apparatus has been tested on a portion of the line from the Dartmouth Arms to Croydon, about five miles in length. These (with the South Devon) are the only lines at present in course of construction on this system; for although projects for atmospheric railways from Epsom to Portsmouth, from Sydenham to Ashford, from Sydenham to Chatham, from Newcastle to Berwick, and from Dalkey to Bray, near Dublin, were introduced in the last session of Parliament, none were passed into a law.

The points to be determined in respect to atmospheric railways, both commercial and scientific, are many. Sir John MacNeil, in a Report to the Dublin and Cashel Company, in reference to the kind of traction to be employed on that line, objected to the atmospheric system on many grounds. He thought that, if an accident or derangement occur, it is more easily reparable on a locomotive than on an atmospheric line; that in all cases of crossing from one line of rails to another, and passing into "sidings," the atmospheric system presents obstacles not found in the other; that any sinking or shifting of the ground would derange an atmospheric more than a locomotive line, since it has a tube as well as rails to be affected; that there would be no power of "backing" a train at a station, which is often requisite; besides certain objections on the score of expense. Mr. Stephenson, in a similar Report, enunciated somewhat similar views. On the other hand, many eminent engineers have given in their adhesion to the soundness of the principle; and the future must show who are in the right.

Present state of British Railways.

It seems almost a dream to look back upon what has been effected in the railway system within the short space of fifteen years; for it was not till the opening of the Liverpool and Manchester line in 1830 that confidence was given to the exertions in other quarters. Between the years 1801 and 1840, about three hundred railway acts were passed, relating either to the construction of new railways or the amendment of others before authorized, involving a length of about three thousand miles of railway; but of this number no fewer than two hundred and twenty were passed in ten years, from 1830 to 1840.

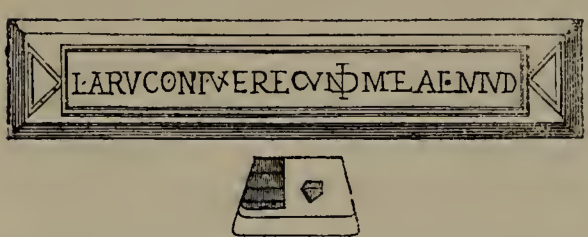
In the article 'Railways,' published in the 'Penny Cyclopædia' in 1841, was given a valuable table of the railways for which acts of parliament had up to the end of 1840 been obtained. It omitted a small number which had never been put in operation; but it gave particulars of one hundred and twenty-four railways, of which ninety-eight were in England and Wales, nineteen in Scotland, and seven in Ireland. Respecting all of these, details are given concerning the length of the line, the course taken by it, the date of the act, the date of the opening, the branches springing from it, the power used (locomotive or stationary), the original capital, and the capital actually expended—so far as the means were afforded for giving these particulars. In reference to them it is there said:—"The total length of the lines sanctioned by acts of parliament is near three thousand miles, of which a few have been either partially or entirely abandoned. Omitting lines of little public interest, those intended for the conveyance of passengers and merchandise by steam-power amount to upwards of two thousand miles, of which more than eleven hundred miles are now in operation. The total amount of capital is 68,825,293*l.*, of which near one-third is allowed to be raised by loan. Deducting the capital of lines not proceeded with, or of only private interest, and making ample allowance for sums authorized but not required, it appears that about 60,000,000*l.* has been invested in this country alone, in the introduction of a system which, but a few years since, had to struggle into existence through opposition arising perhaps as much from incredulity and ignorance as from self-interest."

The above details may be considered to have brought down the state of railway matters to the end of the year 1840. Since then an immense addition has been made, as is well known. During the year 1841, about two hundred and fifty miles of railway were opened; comprising some portions of lines which had been partially opened before; the completing portions of other lines, and the first portion of a third set; but no line appears to have been entirely opened in that year. In the next following year, 1842, a smaller length of new line was added, amounting to about a hundred and eighty miles. In 1843 the number of miles was yet smaller, being very little above a hundred, newly opened to the public. The next year, 1844, was the opening of an extraordinary epoch in railways, to which we shall allude presently.

During the progress of the railway-system, one of the most striking features connected with it has been the lowering of the fares generally, and the increase of accommodation to the humbler classes of travellers. The tax imposed by government has had a good deal to do with this matter. When railways began to injure the stage-coach and post-horse proprietors, a tax was laid upon railways, as an equivalent in some respects to the stage-coach and post-horse duties. This tax consisted of a fixed payment of one-eighth of a penny per mile on all the persons conveyed on a railway: whether first, second, or third-class passengers. On fares amounting to twopence or threepence per mile, this tax was not felt to fall very heavily; but on third-class fares, of a penny or three-halfpence, it became a more serious matter, and, as in the case of many other taxes, bore most seriously on those least able to support it. On some lines, where steam-boat competition compelled the railway companies to carry at exceedingly low fares, the passenger-tax amounted to as much as 15 or 20 per cent. of the gross receipts; whereas the best companies paid on an average less than 5 per cent. In consequence of the complaints made against this system, a power was given to the Treasury to compound with the poorer companies for a fixed sum instead of a toll per head. A better system, however, was introduced in 1842, by fixing the passenger-toll at 5 per cent. on the gross receipt, let the class of passengers and the rate of fares be what they may. This is a much better plan for all parties; since the companies can now accommodate their arrangements to the particular wants of the district through which a railway passes. One effect of this change has been, an enormous increase in the number

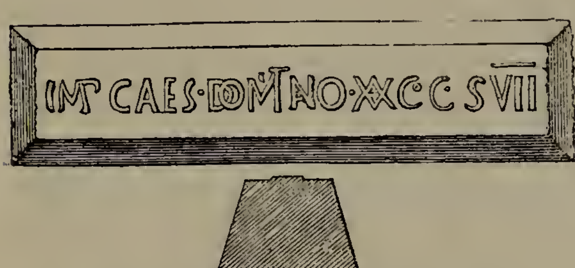
1007.—Specimens of Roman Manufactures in Metal, found in Britain.

1012.—Ancient Metal Flagon.

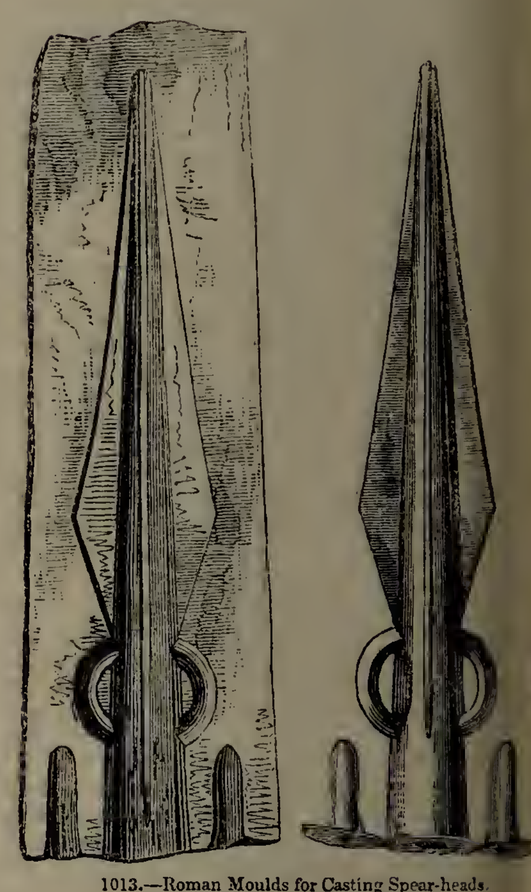


1008.—Plan and Section of a Roman Pig of Lead.

1010.—Plan and Section of a Roman Pig of Lead.



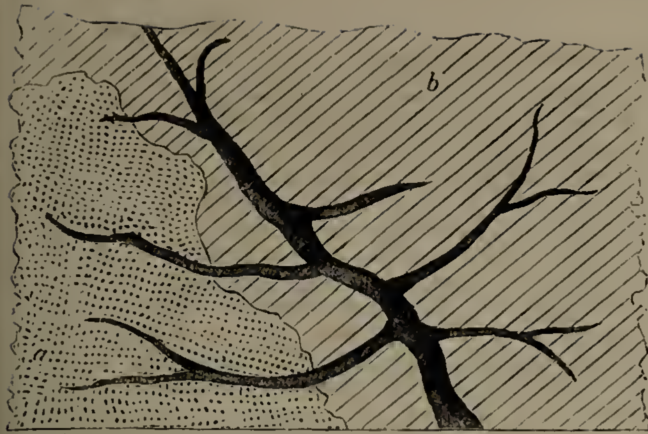
1009.—Plan and Section of a Roman Pig of Lead.



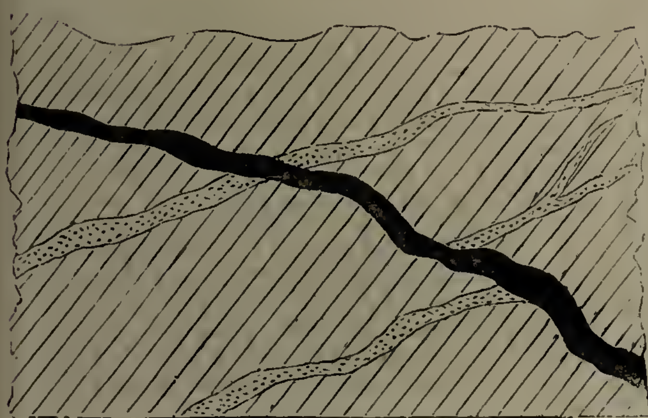
1013.—Roman Moulds for Casting Spear-heads.

1011.—Three representations of a Roman Bronze Bowl, found in Wiltshire.

1014.—Ancient Metal Drinking-cup.

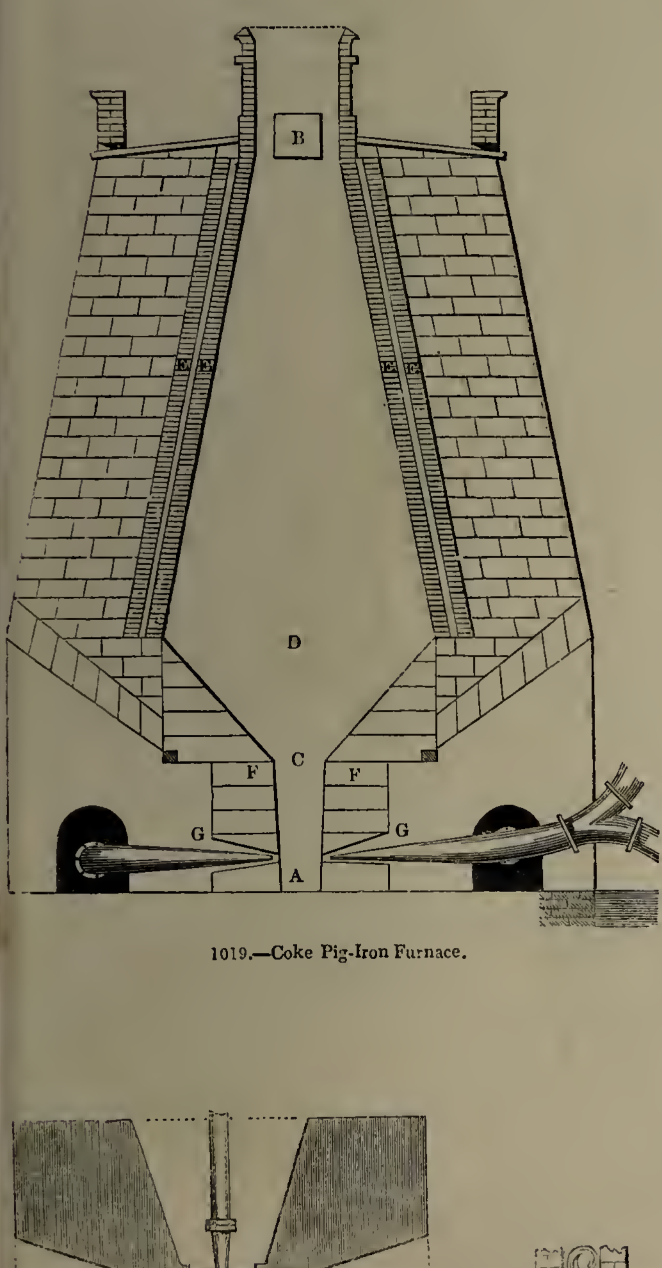


1015.—Metallic Veins traversing Rock.

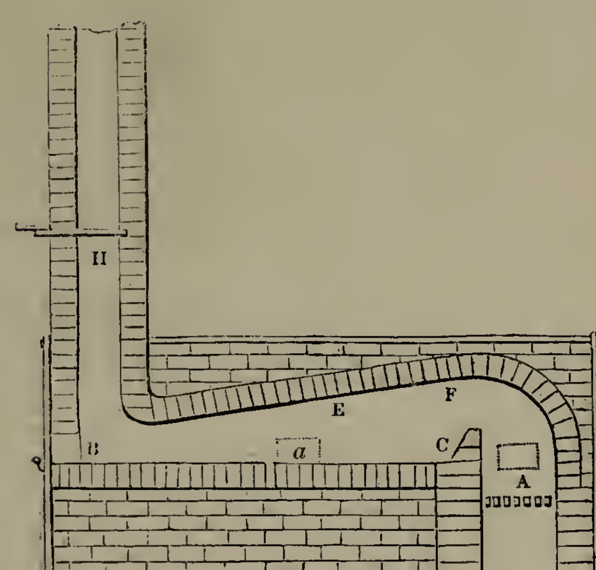


1016.—Metallic Veins traversing Rock.

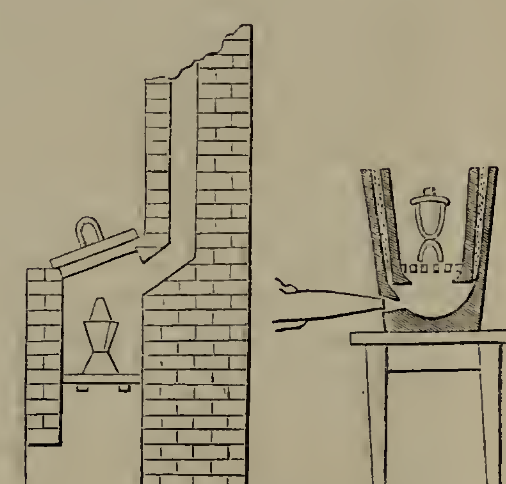
1017.—Boulton and Watt's Soho Works.



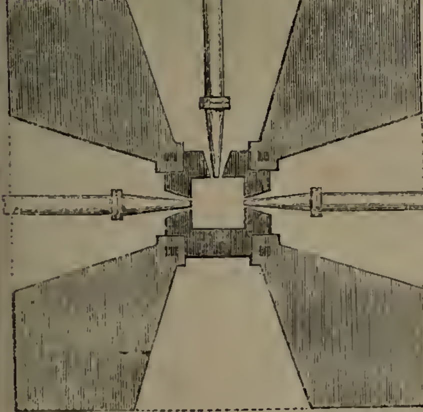
1019.—Coke Pig-Iron Furnace.



1022.—Reverberating Furnace.



1023.—Wind and Blast Furnaces.



1020.—Plan of Blast Furnace.

1021.—Reverberating Furnace,

1018.—Boulton and Watt's Soho Works, as sketched in 1798.

of third-class passengers, especially for holiday excursions on various lines of railway.

The year 1844 brought forward an astonishing number of new railway projects. For two or three years before that period, a certain stagnation of trade in the country had damped the ardour of speculators in railways; but the year 1844 revived it. In the 'Companion to the British Almanac' for 1845, after stating that railway projects were few in number up to 1834, it is observed that—"In 1835, 1836, and 1837, railway projects stood in a very different position. During these years numberless schemes started before a public excited to a pitch of speculative mania which produced, in many instances, most unfortunate results; and the whole face of the country was mapped out with lines, which, though sometimes not well considered as parts of a great whole, have supplied, as far as they have been carried out, tolerably direct railway communication between London, Derby, Nottingham, Sheffield, Leeds, York, and Darlington, in one direction; between London, Bristol and Exeter, London and Brighton, Dover, Colchester, and Bishop's Stortford, by other trunk lines; and by cross lines between Gloucester, Birmingham, and Derby, and Manchester, Leeds, and Hull; as well as extending the first great northward lines by Birmingham and Preston, as far as Lancaster; and establishing some isolated lines in this country, as well as in Scotland and in Ireland. The parliamentary session of 1837, however, witnessed the introduction of certain restrictions upon the facility of obtaining railway Acts; which, taken in connexion with the reaction which usually follows a speculative fever, imposed a severe check upon new projects, and caused many which had been long in contemplation, but had not yet received parliamentary sanction, to be abandoned, or at least allowed to lie dormant. How completely this species of enterprise was checked will be seen from the fact that, while Acts were passed during the three years above mentioned for about fifty new lines, extending to an aggregate length of upwards of sixteen hundred miles, the years 1838 and 1839 produced only five new lines, of the aggregate length of about ninety-two miles."

It required the six years from 1838 to 1843, inclusive, to recover from the mania of 1837 and the two preceding years; and it was not till 1844 that the railway speculators again rushed into new schemes. In that year, parliamentary sanction was obtained for twenty-six new railways, or branches from old railways, extending to a length of 797 miles; involving a share capital of upwards of eleven millions sterling, and a total capital of nearly fifteen millions.

No part of the anticipations of the original projectors of the railway system has been so fully borne out, or even exceeded, as the number of passengers who travel by railway. The anticipations of "goods' traffic" were greatly overrated; but not so those of passengers' traffic. The numbers are truly remarkable. From Returns made to the Board of Trade, it appears that in the year ending July 1, 1842, the number of railway travellers was 18,453,504: of whom 2,926,980 were first-class, 7,611,966 second-class, 5,332,501 third-class, and 2,582,057 whose class is not distinguished. The ratio between the three classes was about 18 per cent. first-class, 50 per cent. second, and 32 per cent. third. The sum paid by these travellers was 2,731,687*l.*; besides a sum of 1,088,835*l.* for goods' traffic. By a subsequent Return, it appears that in the year ending April, 1844, the number of passengers had increased to about 24,000,000, who travelled on an average about fifteen miles each; making the enormous amount of three hundred and sixty millions of miles travelled in one year! Since that time the "pleasure-trip" system on the Dover, the Brighton, the Croydon, the Manchester and Leeds, and many other lines, has come into increased operation; and this, together with the opening of new lines (of which 173 miles were opened in 1844), has occasioned a very large increase in the already high numbers above given.

But great and busy as the year 1844 undoubtedly was, it has been exceeded by its successor 1845. Long will be remembered the absorbing interest of railway matters in the year now passing before us. The rush for railway shares on the part of those who could pay no more than the deposit on them; the insensate desire to purchase "scrip" at almost any premium; the manufacture of new railway companies at the rate (in some instances) of eight or ten in a day; the jugglery in the allotment and sale of shares; the increase of railway journals from two or three to eight or ten; the springing up of the avocation of a "share-broker" into importance, in every part of England; the "bull" and "bear" and "time" bargains (to use Stock-Exchange phrases) in shares; the feverish anxiety with which speculators looked out, first for the "Reports" of the Board of Trade, and then for the decisions of Committee X or Committee A, or as many committees as a double alphabet could give; the serious animadversions of some journals, and the good-humoured satire of others, from 'Punch' downwards; the fierce battles of contending companies; the conflicting evidence of engineers, by which black is proved to be white, and white black—all will be remembered as having peculiarly marked 1845 as the great railway year. What the future will bring in these matters, it would be bold to guess; but the prospect for next year is not much less extensive, if at all, than that of 1845.

The parliamentary session just terminated (August, 1845) has indeed been an active one in railway matters. No less a number than 250 schemes were brought forward at the commencement of the session; and although many of these were disapproved by the Board of Trade, others thrown out by the "Standing Orders" Committee, and others lost in subsequent stages, the number actually passed, and now legally formed, is surprisingly large. The Royal Assent has been given to 120 Acts of Parliament this session relating to railway matters. Of these, 95 were for new railways in Great Britain, 12 in Ireland, and 13 for increased powers, amalgamation, &c. The length of the new lines authorized is 2841 miles: the capital required for them, 44,322,235*l.*; the expected revenue (so far as such estimates are to be depended on) 4,672,264*l.* annually; and the sum appropriable for dividend (supposing the two former items to be correct) 2,817,311*l.*; being somewhat above 6 per cent. on the capital.

One of the peculiarities of the railway system is, that if a Company ever becomes firmly established, its range of operations grows imperceptibly but surely; so that the original name by which the Company was known ceases to represent its real character. The "Great Western"—great in every sense of the term—is perhaps the most appropriately named among them all: it first embraced the line from London to Bristol; then came, by lease, the Bristol and Exeter; and, by purchase, the Swindon and Gloucester; next, the Exeter and Plymouth, now in course of construction, will probably be absorbed in the same system; recently, lines from Weymouth towards Bath, from Reading to Basingstock, from Oxford to Rugby, from Oxford to Wolverhampton, from Monmouth to Hereford, and from the Severn through South Wales to Fishguard—have been conceded, either to the Great Western Company *per se*, or under circumstances which will place them all ultimately under its control; and in addition to all these, the note of preparation is being sounded for other applications to Parliament, for lines through the centre of Wales, and through Devonshire and Cornwall, all in connexion with the Great Western. This vast commercial body (for so it may well be termed) have already expended nearly eight millions sterling, besides the leasing arrangements, and the prospective capital for the new branches.

The London and Birmingham Company, in like manner, have extended their capital from two millions and a half (at which it was first fixed) to something like eight millions, besides a subscription of a million towards the Chester and Holyhead line, and a constantly accumulating power in other quarters. The Report recently issued by that Company (August, 1845) places in a striking point of view the vast scale on which the operations are conducted. In the half-year ending June, 1845, the passenger mileage—that is, the aggregate number of miles travelled on the Birmingham line by all the passengers—was nearly forty million miles, being more than half as much again as in the corresponding half of the year 1844. The carriage of goods was equivalent to about nine million tons carried one mile. The total receipts for the half-year fell but little short of half a million sterling; and considering that the autumnal half-year is always better than the spring half-year, there is little doubt that the gross receipts of the year will exceed one million sterling! The working expenses amounted to about 30 per cent. of this sum.

Another remarkable point is the effect of "amalgamation" in increasing the power of a Company. The "Midland" Company is a notable example of this. Until a year or two ago there were three distinct Companies, the "North Midland," the "Midland Counties," and the "Birmingham and Derby;" of the respective lengths of 73, 57, and 49 miles. These three, after great competition and many disasters, amalgamated into one Company on certain prescribed terms, forming together the "Midland" line of about 179 miles. Since then, this great Company has either bought up or leased the Sheffield and Rotherham, the Leicester and Leamington, the Birmingham and Gloucester, and the Bristol and Gloucester Railways; it has offered to lease the Sheffield and Manchester, and other lines in various directions; it has recently obtained parliamentary sanction for lines from Nottingham to Lincoln, and from Syston to Peterborough; it is forming gigantic plans for new extensions and branches in every direction; and it has agreed to buy up certain canals traversing the Midland districts. Indeed, unless parliament should think proper to check this vast increase of power, it seems not improbable that the whole of the North and South system from Bristol and Rugby up to Berwick will one day be incorporated into one Company.

Whether the financial condition of the country will supply this fearful demand of capital within a few years, time must prove; but the whole system shows how powerful is now the tendency to improve in every practicable way the means of intercourse between one part of the country and another; for however mighty may be these undertakings, they are after all only manifestations of the moving power which governs the "*Arts Relating to Land-Travelling*,"—which subject we here bring to a close.

CHAPTER VII.

THE ARTS RELATING TO METALS AND THEIR MANUFACTURE.

WE may now look back and see how far the details hitherto given have extended in relation to the productive arts whereby the daily wants of social life are supplied.

First, a glance was taken at the principal among those arts whose object is the obtainment of food: many industrial employments connected with this department scarcely admit of being so classed; but still there are several others which have afforded materials for many illustrated details appropriate to the subject of this volume. Next was taken up the subject of those curious branches of art by which a supply is obtained of water, light, and fire: arts embracing a much wider field of operation, and calling forth a larger amount of inventive ingenuity, than is ordinarily supposed. Then came that very large and complex subject, the arts relating to the supply of clothing; a subject more extensive, in a commercial and manufacturing point of view, than any other to which attention is directed in this country. Next—less extensive, certainly, but hardly less important to our comfort—came under review those arts which are connected with dwellings or shelter, whether regarded simply as a screen from the cold and wind and rain above and around us, or as contributing to the decorative and tasteful arrangement of the things by which we are surrounded. From this we extended our survey to a sphere further removed from self, by showing how distant nations and countries maintain intercourse one with another, and how large and important are the industrial arrangements connected therewith, whether bearing most closely on the wants of those who "go down to the sea in ships," or to those who remain on terra firma—whether to those who jog on at two or three miles an hour, or to those who will not be content with a less rate of speed than fifty—whether those who travel for business, or those who are in search of pleasure.

In commencing now a chapter relating to the arts bearing more or less on the transformation of the crude materials of the earth into useful or ornamental products, it may be well to remark, that many such arts have already engaged our attention in a partial degree. In every department of productive industry the use of *metal* is indispensable in some way or other, and thus the manufacture of articles in metal becomes in some sense a part of every department of productive art. Still this is only an incidental connexion, and leaves open to us the consideration of the chief means by which ores, after being dug from the ground, are brought into a state fitted for the purposes of every-day life.

To attempt to express in words the value which metals possess in respect to man, were idle. The savage, who will give almost anything he may possess in exchange for an old rusty knife, expresses it much better than we can. Metals are the most valuable mineral products of the earth; and of these iron occupies the first rank. It has been well said, that "Of all the substances which we derive from the bowels of the earth, this is the most indispensable to our wants. In whatever situation we may be placed, we cannot look around us without iron meeting our eye in some shape or other; and even where it is not seen, it has been more or less employed in producing almost every object that ministers to our necessities, our comforts, or our luxuries: in short, it has been one of the great instruments by which the civilization of the human race has been accomplished."

That the metals have been objects of attention in all ages, we have abundant evidence. Sometimes an old relic is dug up from buried ruins; sometimes a tomb is opened, and is found to contain urns or other articles in metal; at other times a bas-relief, or a rude painting, or an illuminated MS., according to the place where, and the period when it was produced, reveals to us the existence of metallurgic arts in bygone times. In Fig. 1007, for instance, we have a group of metal instruments of very varied kind, copied from specimens dug up in various Roman remains in this country; in Fig. 1011 is a bronze bowl, similarly found, and very elaborately decorated; in Fig. 1013 is a Roman mould, intended, as is supposed, for casting Roman spear-heads; in Figs. 1008, 1009, 1010, are representations of Roman pigs of lead, found in the northern parts of Britain; in Fig. 1024 is the miner's standard dish—of much later date, certainly, than the other objects of which we have been speaking, but still a curious symbol of early metallurgy, of which we shall have occasion to speak further in a future page; in Fig. 1025 is a copy of a curious illumination to a MS., showing the operations at a smithy, with the extraordinary contortion of figure in which the Anglo-Saxon artists sometimes indulged—all these exemplifications, more or less important in their way, point to the metals as having been busily operated on in times long gone by.

IRON: ITS SOURCE, EXTRACTION, AND MANUFACTURE.

IT will be impossible to take all the metals, and follow them out from their position in the ground to their final appearance as manufactured articles. But by taking a few of the most prominent as examples of all, the object will be attained with sufficient nearness; and if there is one metal better calculated in every way than others to commence with, it is *iron*. Not only does this pre-eminence show itself in almost every country where iron is used, but in our own country the incalculable value of iron is perhaps more striking than in any other. It is indeed a "precious metal" to us: much more so than those to which this appellation is commonly given. The well-being of our island has depended on the existence of her iron-mines, to a degree which it is exceedingly difficult to estimate properly; when two such bountiful gifts as coal and iron are compared, one is almost disinclined to admit that either is less important than the other; but when both come together as they do in England, we have much to be grateful for. It has been made a subject of remark, as a happy thing for this country, that the iron ore of Great Britain occurs not only in the vicinity of, but actually associated with, the coal necessary to separate the metal from the impurities of the ore. In Sweden, and most other countries where iron-mines exist, the ore is refined by means of wood; but no space on the surface of our island could have been spared to grow timber for such a purpose; and thus, without coal, in place of being, as we now are, great exporters of wrought and unwrought iron to distant nations, we must have depended on other countries for this metal, to the vast detriment of many of our manufactures, which mainly owe their improvement and extension to the abundance and consequent cheapness of iron.

Extracting the Ore from the Earth.

The ores of the various metals are situated very differently in the bowels of the earth. Whatever may have been their origin (and this is one of the most difficult of geological inquiries), it is found that each metal has a general character in respect to its position or arrangement in the earth, and that this arrangement differs from that of many other metals. There are four sorts of arrangement for the metallic ores, viz. *veins*, *beds*, *masses*, and *fragmentary deposits*; the different features of which may be thus shortly illustrated.

The *veins* of metallic ore, including those of copper, tin, lead, zinc, gold, and silver, appear to have been long, narrow, irregular fissures, penetrating very deeply into a rocky stratum, sometimes vertically, and at other times at a high angle. These fissures have, by some internal convulsion of which we know very little, been filled with a sparry or stony substance, called the "veinstone," and containing, in irregular masses or lumps scattered here and there throughout, the ore whose metallic contents is the object of the miner's search. There are therefore the original rock, the fissures in the rock, the veinstone that fills the fissures, the ore contained in the veinstone, and the metal contained in the ore. Figs. 1015, 1016, will illustrate the arrangement of copper veins in various kinds of rock, *a* and *b*.

The next class of mineral deposits, viz. those found in *beds*, are layers of ore interposed between the strata of solid rock; much in the same way as flint forms layers in chalk, and rock salt between other mineral substances. *Masses*, or *pipe-veins*, as they are sometimes called, are deposits contained in irregular branching cavities descending either vertically or obliquely into the rock: these deposits are not so common as the two former, and usually consist of ores either of copper, lead, or iron. The last of the forge kinds, viz. *fragmentary deposits*, are a result of the wasting and gradual removal of the soil in a mineral district. Where veins or beds of metallic ore are contained in a mountain or a lofty district of country, and where the rock or soil is of such a character as to crumble away and roll down by the gradual but incessant action of the atmosphere, beds of loose fragments form in the valleys below, and in these beds are often found fragmentary deposits of the metal from the veins in the upper district. The chief metals which occur in this position are tin and gold; the name of "stream-works" being applied to the mining or industrial arrangements whereby the metal is obtained from these loose deposits.

The "ores" here alluded to are mixtures of the pure metal with a vast variety of earthy substances, all of which must, by some process or other, be removed before the metal can be obtained in a workable state: sometimes small masses of metal are found in a pure state; and in other cases they are met with as "alloys," that is, combined with some other metal or metals; but in the large majority of cases the metals form constituents of ores, being combined with various earthy matters, which completely disguise the metal itself. The modes of separating these earthy impurities differ according to the nature and number of mineral ingredients; but comprising one or more of these four—pounding, washing, calcining, and smelting.

Metallic iron is produced from many different ores of the metal; but by far the larger portion in this country is derived from the ore called the "clay-ironstone." This is in general a bluish grey kind of stone, presenting no appearance whatever of metallic structure. The iron is in the chemical state of a protoxide; and the usual kinds of clay-ironstone are found to contain about forty or fifty per cent. of this protoxide, and about thirty per cent. of carbonic acid; the rest of the ingredients being silica, alumina, lime, magnesia, and minute quantities of one or two other ingredients. The beds of clay-ironstone are found largely associated with coal in some districts of England; and in some parts of the south of Scotland the iron and coal or bituminous matter are found to be happily so well proportioned in quantity, that the coal affords just heat enough to smelt the ore. The ore is sometimes in thin continuous strata; but more frequently there is only one single stratum in one spot where it occurs with coal. The thickness of the strata varies usually from half an inch to half a yard; and there are occasionally also met with rounded nodules or masses, from an inch or two to several feet in length, scattered irregularly through the indurated clay which forms the mass of the earthy substance.

We shall in a future page glance at the processes of mining, which are of more importance in reference to tin or copper than iron. Here it may suffice to say that, after the ground has been excavated to a sufficient degree to afford access to the mineral contents, the layers or strata of ironstone are dug out by means of picks and other tools, shovelled into baskets or boxes, and brought up to the surface, where arrangements are made for smelting; or, if smelting is not carried on near the mine, the ore is conveyed away to the smelting works.

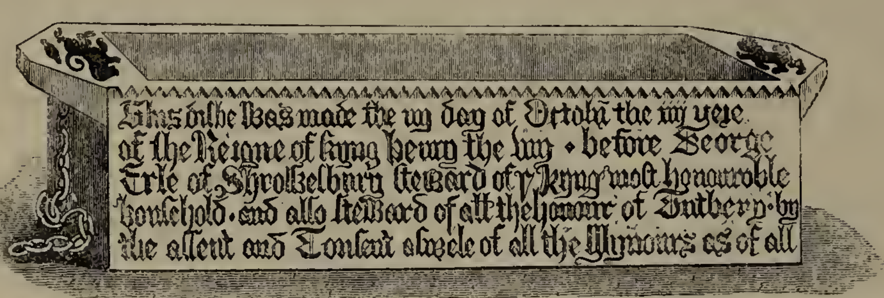
If ironstone contains a good deal of clay, it requires lime to be added to separate the iron; but if the lime be in excess clay is added; since the lime and the clay mutually separate each other from the metal. Hence the arrangements at the smelting works depend a good deal on the sort of ironstone employed.

Iron-furnaces and Smelting-works.

The establishments where iron is smelted (of the interior of one of which a sketch is given in Fig. 1027) are large and striking buildings, the whole operations of which are carried on on a very large scale. The most conspicuous feature is the "blast-furnace," where the materials are exposed to a heat so fierce as to separate the metal from its earthy accompaniments. These blast-furnaces differ in shape in different districts. In North Wales, at the great works of Dowlais and Merthyr Tydvil, the blast-furnace is generally a square mass of masonry, with a base of from thirty to fifty


1027.—The Foundry, or Cast-House, at the Butterley Iron-works.

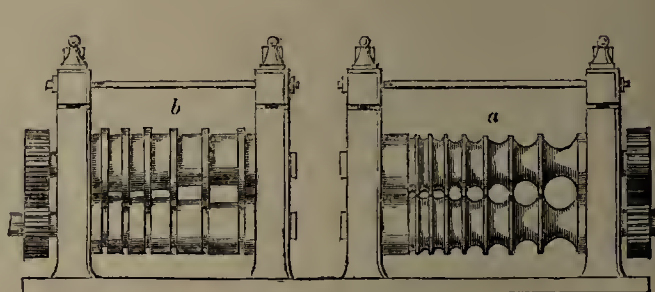

1026.—Filling Blast Furnace.



1024.—Miners' Standard Dish, Wirksworth, Derbyshire.


1025.—Smithy, as represented in an ancient MS.

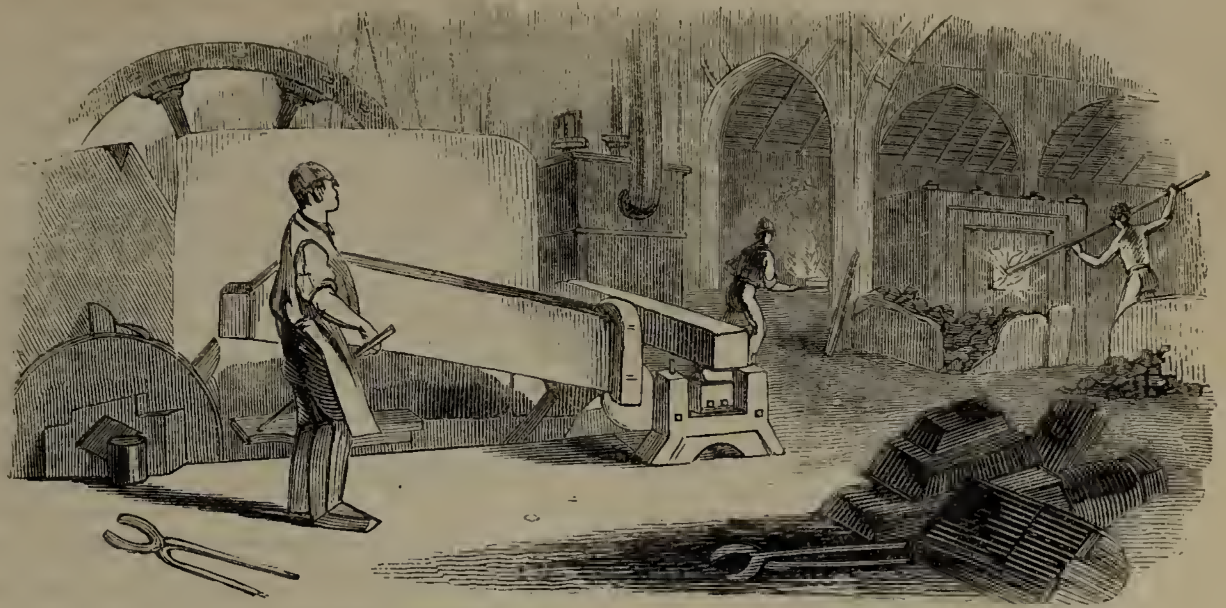

1030.—Steam-Boiler making.



1028.—Bar-Iron Rollers.

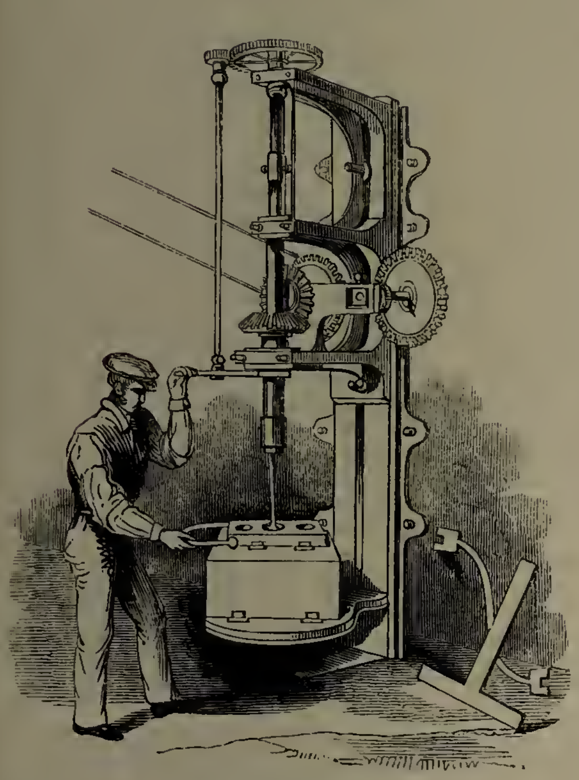

1029.—Rolling Bar-Iron.

1034.—Cutting Sheet-iron.

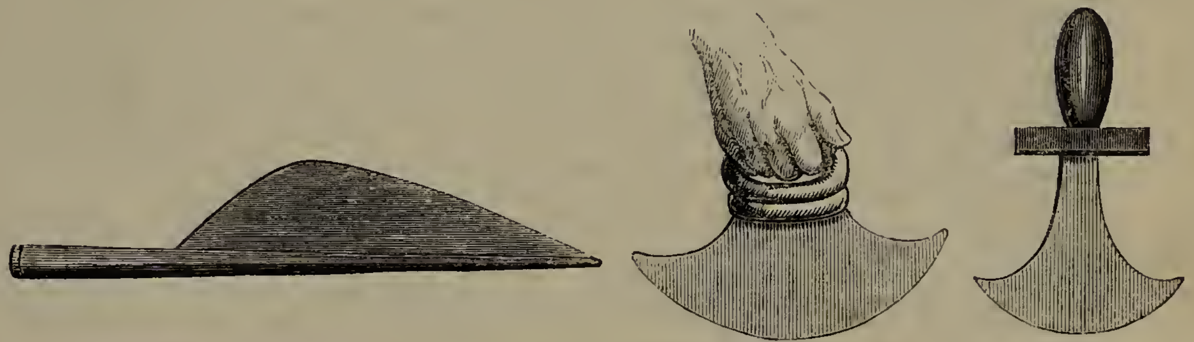


1033.—Puddling-Furnace and Shingling-Hammer: Iron-manufacture.

1031.—Ancient Egyptian Forge or Bellows.

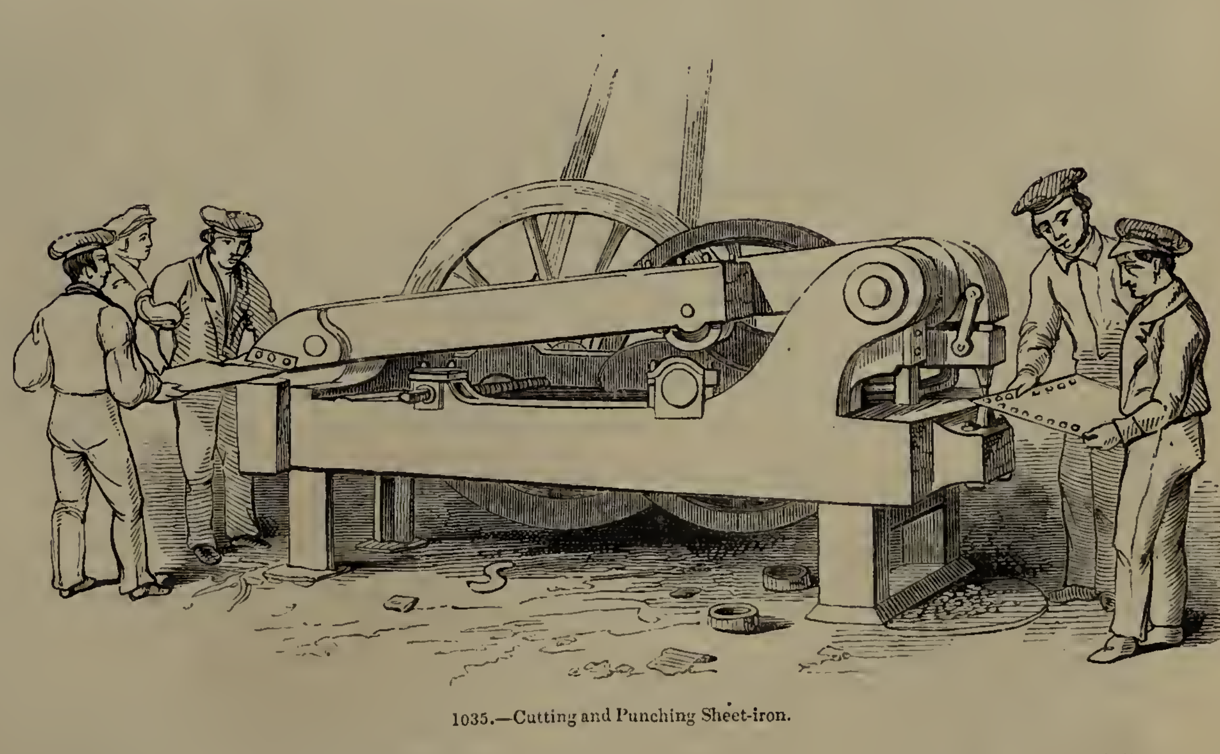


1036.—Boring-machine.



1037.—Ancient Egyptian Knives.

1032.—Casting Iron Pipes.



1035.—Cutting and Punching Sheet-iron.

feet; these dimensions gradually lessening to about twenty-five feet at a height of forty-five feet from the ground. A cylinder of brickwork is then carried on to the height of ten or fifteen feet more, making a total height of about sixty feet. There is a covered communication between the top of the square masonry and the high ground at the back for the purpose of supplying the materials. The cylinder at the top, called the "tunnel head," is furnished with from one to four doors or openings—generally two—opposite each other, through which are introduced the materials for the supply of the furnace. There are four arches in the centres of the four sides, forming recesses in the solid masonry: the one in front is to enable the workmen to manage the flow of the melted metal; while those at the sides are for the introduction of the blast by which the heat is kept up.

Other forms of furnace are adopted in other districts. For instance, near Glasgow there is a large establishment in which six cylindrical furnaces are placed in a row, with a light and elegant cast-iron gallery extending from one to another near the top, and machinery for raising the raw materials for supplying them. It depends a good deal on the degree in which the ground is elevated near the furnace as to the kind of form adopted; since there must be some mode of carrying the materials up nearly to the top, as a means of throwing them into the furnace.

The five cuts from Fig. 1019 to Fig. 1023 will afford the means of showing the arrangements in the interior of an iron-furnace, and the difference betwen this and other furnaces. In Fig. 1021 is shown a "reverberating furnace," with the flame *b* proceeding from the fire at *a*; and in Fig. 1022 the action of the different parts is illustrated somewhat more at full. In this figure, A is a space furnished with a grate or bars to contain the fuel; B, E, F is the part on which the flame acts; E F is the roof; B C the hearth on which the substance to be heated is placed; C is a low wall or bridge, which retains the fuel in its place, and serves to direct the flame towards the roof; *a* is an opening in the side of the furnace for introducing the materials; sometimes there is an opening at B, to allow melted metal to flow out; H is a lofty chimney for producing a draught, which may be regulated by a damper placed across the opening. This kind of furnace owes its name to the circumstance that, from its peculiar construction, the flame and heated air are made to reverberate or echo from the roof of the furnace down upon the materials, whereby a very intense action is produced. Of the two small furnaces sketched in Fig. 1023, the one on the left shows a "wind-furnace;" there is a grating on which the fuel is placed, a crucible or vessel for containing the material to be heated, a door for feeding the fire, an open space for the access of air from beneath, and a tall chimney for exciting draught: it is found that this kind of furnace enables a very intense heat to be obtained, and it is therefore employed in melting steel for casting. The other section in Fig. 1023 represents a miniature "blast-furnace," used for chemical purposes, but depending on the same principle as the large blast-furnaces employed in the iron manufacture. There seems to have been some such plan of keeping up a fierce heat by blowing, adopted from very early times in the metal manufactures; for many of the ancient Egyptian paintings (one of which is copied in Fig. 1031) show indications of this practice, which are valuable as indications, however rude and even ludicrous they may be as pictures.

If we were to select an iron-furnace of the usual construction, and suppose it be cut down through the middle from top to bottom, we should find it to present the various arrangements shown in Fig. 1019. This is a furnace for making "pig" iron, and in which coke is the fuel employed. The height from the bottom at A to the filling-place at B is about fifty feet. The general material of the furnace is brick, lined on the inside at E with a double circle of fire-bricks, having an intervening space filled with sand; F F, the hearth, is composed of large blocks of stone; D is the general cavity of the furnace, filled with the burning materials; and C A is a contraction of the space, to prevent the materials from blocking up the place of exit; G G are the nozzles of two bellows or blowing machines, by which a blast of air is forced in among the glowing contents of the furnace. In Fig. 1020 is given a ground-plan of the furnace, in which these nozzles of the blowing-machine are seen to be directed towards the centre of the hearth or lower part of the furnace.

The arrangement of most of the blast-furnaces has been a good deal affected during the last fifteen years by the introduction of the "hot-blast." Until about the year 1829 it was customary to force cold air into the furnace, for exactly the same object (in principle) as that which prompts the use of bellows in a common fire. It occurred, however, to Mr. Neilson, of Glasgow, that a small quantity of fuel would be judiciously expended in heating the air before introducing it into the furnace; as he suspected that the coldness of the air generally used was a source of much mischief. He embodied the thought in a new invention, which he patented; and seldom indeed has there been a patent more triumphantly successful; for besides doing an incalculable amount of good to the iron-manufacture, it has enriched the inventor himself—a result by no means so general as one would wish to see it.

The iron-stone or iron, as taken from the mine, contains many different ingredients besides iron; such as lime, clay, water, flint, sulphur, and carbonic acid—all, or nearly all, of which must be removed before the iron can be presented in the metallic state. In the first instance the ore is "roasted,"—that is, it is built up into a huge heap or ridge, with layers of coal interstratified with it: the coal being kindled, and a plaster of clay being applied outside to prevent the flame from bursting through the mass, the ore undergoes a kind of slow roasting process, by which all those matters are driven off which will escape in a gaseous form, such as sulphur, carbonic acid, and water, while the remaining ingredients are brought into a better state for smelting. When roasted, the ore is called by the workmen "burnt-mine," whereas it was before known as "raw-mine." The burnt mine, then, is the substance which is thrown into the smelting furnace; and with it are employed other ingredients, according to the kind of iron-stone used, to the kind of iron required to be made, and to the kind of blast employed, whether hot or cold. All these points differ much in different districts; and it will suffice to mention, as an example, that at one of the Derbyshire works, where the hot-blast is used, a particular kind of iron is made by introducing into the furnace two tons thirteen hundred weight of roasted ore, and two tons and a quarter of coal, to one ton of limestone: the coal produces heat to soften and liquefy the ingredients, while the lime abstracts and combines with the clay existing in the iron-stone, thereby leaving the iron to separate in a melted state. All the ingredients are put into a large vessel, which is wheeled along a kind of railway to an opening near the top of the furnace (Fig. 1026); and there, by the use of a simple but ingenious piece of apparatus, the bottom of the vessel is made to open, and the contents fall down into the burning bosom of the furnace beneath. Every three or four hours this supply is renewed, to make up for the sinking of the charge last thrown in; so that the furnace is kept constantly nearly full of burning materials, amounting generally to a hundred or a hundred and twenty tons weight.

At intervals of every few hours, this mighty mass so far yields as to afford a considerable quantity of melted iron, which remains pent up in the lower part of the furnace. Then ensues a very striking scene. There is generally, near the lower part of the furnace, a large extent of sanded floor, in which channels or gutters may easily be made. All being ready, the furnace is "tapped;" that is, a hole is made by a sharp bar at the lower part, and the iron, glistening like molten gold, flows out in a continuous stream, spreading as it flows, and filling all the channels made in the floor of the cast-house (Fig. 1027). The heat excited by the condensed air of the hot-blast, acting on the fuel in the furnace, has had the effect of liquefying the metal, and enabling it to flow with great freedom from the tap-hole. The workmen have an odd vocabulary of terms to this as well as to many other processes; they give the name of "sow" to the large or central channel in the floor into which the metal flows, while the lateral channels into which the iron flows from the main are called "pigs;" and even in commerce these names are retained, for a distinction is kept up between "sow-metal" and "pig-metal."

The Founding and Forging of Iron.

Whether a piece of iron is to be converted into a delicate ornament or into a huge beam for a steam-engine, it is alike obtained from the crude ore by the means described above; but its subsequent history depends a good deal on the purposes to which it is to be applied. For most purposes, the iron is first cast into the form of pigs; but for large castings it is occasionally made to flow at once into the moulds formed for that purpose. Sometimes, for example, there is a mould formed in the sand floor of the cast-house, in such a way that the melted metal may flow direct from the furnace into the mould. In other cases, a ponderous ladle or vessel is sunk in the sand sufficiently for the metal to flow into it; and on the ladle being hoisted out of the sand by means of a powerful crane, the contents may be poured into any mould conveniently placed for its reception. Such is the mode of making large iron pipes (Fig. 1032), in which the melted metal, after being collected in a vessel suspended from a crane, is poured into a trough, from whence it flows into a number of moulds for making pipes.

In the majority of cases, however, the iron is first cast in the form of pigs, and then re-melted in a separate furnace for the purposes of being re-cast into the numerous forms required in the arts. In almost all such examples of casting, the moulds are made of sand, which is a convenient material for receiving the impress from a model or pattern; and there is in many cases a counter-mould for producing hollows or depressions on the back of the article manufactured. For some articles, such as large cylinders for steam-engines, the mould forms rather a bulky affair; there is first built up a cylinder of brickwork, whose *external* surface is plastered and smoothed to give the *internal* surface of the cylinder; there is besides this an external brick shell, whose inner surface is made smooth to give the outer surface to the cylinder; there is a space between the two equal to the intended thickness of the cylinder, and the melted metal is poured into this space; after which, on the cooling of the metal, the external surface is removed, and the cylinder removed from the mould.

Where the object in view is the production of "bar" or "malleable" iron, the processes differ considerably from the above. The proportions of the ingredients put into the furnace for bar-iron are different from those adopted for cast-iron; but the melted metal is cast into "pigs" in both cases. These pigs, for the production of "bar" iron, go through a variety of processes, technically named "refining," "puddling," "blooming," and "rolling:" all of which tend to give the iron a much greater degree of toughness than it before possessed. When in the fit state for making cast-iron, the metal is mixed up with a good deal of carbon and oxygen; but as these are detrimental rather than otherwise to wrought-iron, they are expelled by means of the "refining" and "puddling" processes. The refining is effected in an oblong shallow furnace, having a hearth or bottom of fire-bricks, and hollow sides of iron, the hollow being kept constantly filled with water to prevent the burning of the metal. Into this furnace the pigs of iron are thrown, and are there exposed to an intense heat, which liquefies the metal and drives off some of the impurities. A hole is opened in the lower part of the furnace, and the liquid metal flows out into shallow iron trays or moulds, where it cools quickly, and acquires a degree of brittleness which enables it to be broken with much ease. It is broken into fragments, which are thrown into the "puddling-furnace," there to undergo another ordeal of fierce heating. This furnace is of the kind before alluded to as "reverberating;" that is, having an arched roof so constructed as to allow the flame and heated air to be echoed down upon the contents of the furnace. The process is a very trying one for the men engaged at it; for the "puddler" has to stand in front of the furnace, and watch the progress of the operation through a hole; he has also to keep the mass of melted iron constantly stirred by long bars inserted through the hole: each bar becomes speedily red-hot, and he plunges it into water, and replaces it by another from time to time. By this process the iron becomes thickened, and assumes the form of a pasty mass; and the "puddler" so manages the mass by means of his bars, that he separates the whole contents of the furnace into five or six irregular lumps called "balls" or "blooms," of sixty or seventy pounds' weight each. The right-hand portion of Fig. 1033 represents some of these operations.

The iron, it must be borne in mind, has now reached the state of a glowing red-hot pasty mass; and the reduction of this mass to a regular shape is the object of the next stage of operations—not less curious and interesting than those which have preceded it. The fiery ball passes rapidly from one machine to another, requiring on the part of the workman a mingled strength of muscle and power of heat-endurance, such as startle many a by-stander. A man takes in his hand an instrument shaped something like a long pair of tongs, and by means of it takes one of the "balls" or "blooms" out of the furnace; the bloom is placed upon an anvil, and a huge hammer of most enormous weight is made to act upon it; sometimes this hammer, called the "shingling-hammer," weighs ten thousand pounds; and by its means the red-hot mass of iron is worked into the form of an oblong rectangular piece. While yet hot, this piece of iron is taken by means of tongs to the "puddle-rolls" (Fig. 1029). These are rollers of vast strength working one against another, and so grooved at the surfaces as to allow bars of iron to pass between them; the grooves are of various sizes; and the oblong piece of hot iron is passed successively through several of them, beginning with the largest. One man holds the iron in such a way that it may be caught by the rollers and drawn through, while another receives it after its passage and hands it back again. By this chain of processes the iron has been made gradually smaller in width and thickness, but of greater length, until it has attained the form of a rough flattish bar two or three yards in length.

Notwithstanding these many beatings and processes, the metal has not yet acquired the toughness necessary to be possessed by wrought-iron. The rough bars are cut into short pieces, made up into groups of five or six each, and put into "balling-furnaces," shaped very much like the puddling-furnace. Here the group is brought to a welding-heat, and is then fitted to be drawn through rollers for the production of bars, rods, railway-bars, sheets, and other forms of wrought-iron. This drawing or rolling is the same in principle as that before alluded to; viz., the metal is drawn through grooves, smaller and smaller in diameter as the bar be-

comes reduced in thickness; and these grooves may be square or triangular, flat or round, according to the kind of bar required to be produced. For instance, in Fig. 1028, the two rollers *a* are fitted to produce cylindrical bars; whereas those at *b* are for flat bars. If the wrought-iron is to be brought into the state of sheets instead of bars, the surfaces of the rollers are left smooth, and the two rollers of each pair are placed at a distance apart equal to the intended thickness of the sheet.

Preparing Wrought-Iron for Manufactures.

It is considered that the business of the iron manufacturer ceases when he has brought the iron to the state of pigs, if for cast-iron; or to the states of bars or sheets, if for wrought-iron. Beyond these points, the practical application of iron belongs to one or other of the numerous departments into which metallurgy is divided. The engineer, the machinist, the millwright, the wire-drawer, the steel-maker, the cutler, the needle-maker—all take up the operations at the point where the iron-maker leaves them. Some of these ulterior processes will come under our notice presently; but it may be well here to glance at a few mechanical processes which the iron undergoes to prepare it for more minute subdivision and application—such as "cutting," "boring," "drilling," "planing," &c.; operations which form an important part of the labours at the great engineering establishments, such as that which has become immortalized in connexion with the name of Watt. (Figs. 1017, 1018.)

When sheet-iron is to be used for boilers or other purposes, it requires first to be cut into pieces of definite shape and size, and then to have holes bored for the reception of the rivets by which the several pieces are fastened together. The cutting is effected by instruments of different kinds, according to the thickness of the sheets; but the instrument is generally a kind of enormous shears, worked by a steam-engine. In Fig. 1034, for instance, the sheet of iron is held by two men, and thrust in between the jaws or blades of a kind of shears, by which strips are cut off as easily as if it were paper. In Fig. 1035 the machine employed is a larger one, and ingeniously contrived for effecting two operations at once: at one end is a pair of shears, by which the sheets of iron are cut into pieces; while at the other end there is a punch for making rivet-holes. It is from sheets of iron, cut and punched in this way, that the huge boilers for steam-engines and steam-vessels (Fig. 1030) are often made: sometimes they are of copper, and at other times of iron; but, in either case, the sheets of which they are formed are fastened together mainly by means of rivets driven into holes in the doubled edges. There is perhaps scarcely any other department of manufacture in which the noise is so deafening as that resulting from this process, especially where, as in some cases, it is carried on under a roofed building.

Another process is that of "boring." After a cylinder or a barrel has been cast in sand, in the way before described, the internal surface, although presenting a general cylindrical form, is too rough for the nice adjustments required in engineering; and it has consequently to be rendered smooth by the action of a cutting instrument. The term "boring," applied to such a process, is perhaps not quite a fitting one; since we should understand by it rather the making of a hole than the mere perfecting of it when made. Some of the large cylinders for steam-engines, five or six feet in diameter, require the use of boring-machines of immense magnitude and power. Each such machine consists of a long bar or axis, which is made to pass through the cylinder, and from which project arms, having cutting points of steel at their extremities; these points come in contact with the internal surface of the cylinder; and by being made to rotate rapidly they scrape off minute fragments of iron: this being continued from end to end, by the advance either of the machine or of the cylinder, the whole inner surface becomes scraped smooth. In the large machines the boring-rod generally works horizontally; but in smaller machines, for finishing holes in cast-iron pieces of small size, it is vertical (Fig. 1036). This smaller kind of boring-machine does not differ very much in principle from the "drilling-machine" (Fig. 1038), in which a sharp point of well-tempered steel, fixed to the bottom of a vertical rod, is made to rotate with such velocity as to drill a hole in any piece of metal which may be placed beneath. If the metal be a piece of sheet-iron, holes in it are usually made by punching; if it be plate-iron of greater thickness, the holes are made by drilling; where it is a thick piece of cast-iron, the holes are generally made in the casting, and afterwards completed by the boring-machine.

A machine of great power and accuracy is used for planing the surface of metal (Fig. 1039), by which a truthfulness of level is obtained which could not result from any other process: indeed, much of the beauty of modern mechanism is due to the use of the planing machine. The flat piece of iron which is to be planed, whether it be a large plate or a long bar, is laid down perfectly horizontal on a bench, where the planing-machine may act upon it. This machine has a sharp steel cutter fixed at the lower part, the edge of which is brought to bear upon the surface of the iron; the whole surface is scraped successively by this edge, so as to give perfect regularity to every part. This machine is the same, in respect to its principle of action, as the boring-machine, since the effect is in both produced by this scraping action; the difference observable being due to the different kind of surface operated upon.

"Turning" is another process whereby the surface of iron is brought to the requisite degree of smoothness. It is effected nearly in the same way as wood-turning; the article to be turned being fixed horizontally in a lathe, and a cutting tool being made to act upon every part of the surface in succession (Fig. 1045). In wood-turning, however, the fragments are taken off in the shape of shavings and chippings; whereas in metal-turning they are much finer.

It is by such processes as the above, and others of analogous character, requiring the aid of very ingeniously constructed machines, that castings, bars, plates, and sheets of iron are brought into the various forms required for the countless purposes of every-day life. Some of these purposes have already engaged our attention; others will call for a passing glance as we proceed.

Making of Wire, Nails, and Screws.

A very large number of useful articles is made from iron brought to the state of small slender rods. Wire, nails, and screws are among this number; and they will serve to convey an idea of many others.

Wire-making, or "wire-drawing," as it is more usually termed, is but an extension of bar-iron rolling, so far as concerns the gradually lengthening and attenuation of the metal; but the effect is brought about by different means. In "rolling," the metal is made red-hot, and is in that state drawn between rollers; whereas in "drawing," the metal, while yet cold, is drawn through a hole somewhat smaller than the bar or rod in diameter. There are, however, many curious points in the mode by which the effect is produced. In early times, when wire or narrow strips of metal were required, the metal was hammered into the form of thin plates, these plates were cut up into narrow ribands, and the ribands were either hammered or filed into a roundish form. At a later period the "drawing-iron" was invented, by which the metal was brought to the required state by drawing it through a hole; but the rods were produced by a laborious process of hammering before the drawing commenced; and it was not till the combined processes of "rolling" and "drawing" were adopted that wire could be made as in the modern method.

The rods of iron for wire are brought by the rolling-mill to a thickness of about a sixth of an inch; they are twisted round into coils; and these coils are well washed in sand and water, to take off all dirt and impurities from the surface. In the best wire-drawing establishments at the present day the arrangements are such as are sketched in Fig. 1040. Several cylindrical drums or barrels are ranged in two rows on a work-bench, each fixed on a vertical axis, and all being enabled to rotate rapidly by straps and bands from a steam-engine. Close to each drum is a "draw-plate," which consists of an exceedingly hard plate of steel with a well-drilled hole or holes in it. Supposing there to be twelve drums in one series, the plates connected with them have holes of twelve different sizes, through most or the whole of which the wire is made to pass during its formation. Following a coil of iron rod through its successive stages of progress, we should find that it is hung on a peg near the drawing-bench; and one end, being uncoiled and filed thin, is inserted into the largest hole in one of the draw-plates. The drum is then made to rotate, by which the metal is forced through the hole, its diameter reduced, and coiled round the drum. It is then removed to a drum and plate having a hole next smaller in size, through which it is drawn. And so on through a great many different stages; the diameter of the wire being decreased and the length increased at each stage. The number of holes through which the wire is drawn depends on the diameter required to be obtained; and this diameter, for iron wire, varies from about one-fiftieth to three-tenths of an inch. This gradual reduction requires much tact and management; for if an attempt were made to draw the wire through a hole of much smaller diameter than itself, the wire would break. Even when the proper sized holes are used, the wire becomes so hard and brittle by the compression that it requires several annealings during the operation. This annealing is done in a curious way. There is a large oven or cell, three or four feet in diameter by eight or ten deep, and in this the coils of wire are placed to be annealed by heating. By placing small coils within the larger ones, as much as twenty or thirty cwt. of wire can be placed in the kiln at once. The kilns are made of iron, cased externally with brick-work; and when the wire is put in, every aperture is closed, the fire is kindled beneath, and a great heat is excited. The gradual cooling from a high temperature has the effect of annealing the wire, and it is then in a fit state to be drawn again through the plates. Iron which has been smelted with charcoal, instead of with coal, is found to bear the greatest amount of drawing without annealing. Sometimes, for making fine wire, the process of annealing is required to be conducted as many as eight times.

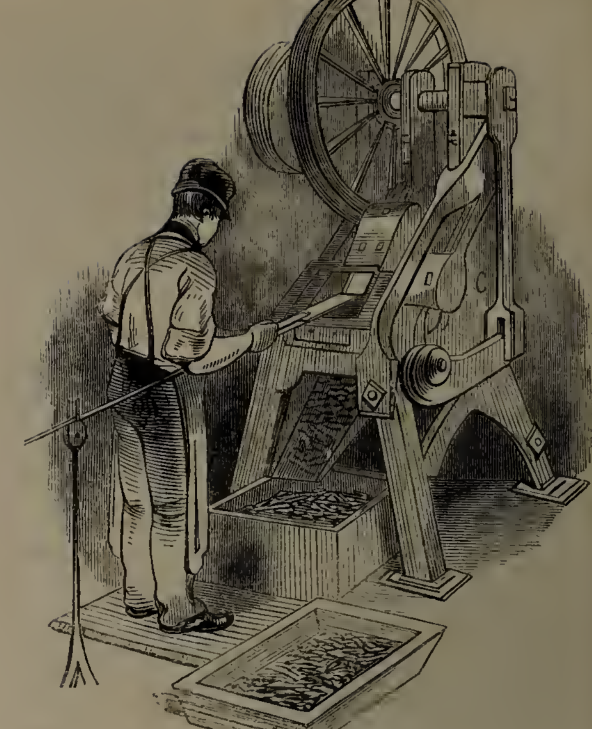
In making *nails*, the iron is sometimes brought to the state of thick wire as a preparative step; but more usually this is not requisite. A distinction between "wrought" and "cut" nails gives rise to many peculiarities in the manufacture; since the former are made from small rods, and the latter from sheets: the former are made by hand, and the latter by machinery; the former are made in small cottages or workshops, and the latter in large factories, where steam-engines supply the moving power. It may be well to speak of the former of these two kinds first.

Whoever has occasion to pass along the public roads between Birmingham and the adjacent towns of Dudley, Walsall, Wolverhampton, &c., will be pretty sure to see indications of wrought-nail making. Here and there an open door will afford a glance into a rude kind of smithy or shop, where three or four persons are hammering away, and where a smithy fire affords the means of heating the iron. Along the road, too, may be seen persons carrying bundles of iron rods, which they have purchased of the iron merchants, and are about to convert into nails at their own dwellings. The rods are made of iron which has been rolled in sheets of the requisite thickness, and then cut up by slitting rollers into pieces having the requisite width for nails. The working up of these rods into nails is an operation in which all the members of a family frequently assist. In the first place, one end of a rod is placed in the forge-fire, and heated by the aid of two or three blasts from small bellows. The "nailor" takes it out of the fire and rests it on his anvil, which is a small cube of steel imbedded in a mass of iron. With a few dexterous blows from his hammer he quickly fashions the end of the rod into the required shape for a nail; and then cuts off the portion thus prepared. Another heating and another hammering produce a second nail; and so he goes on until the whole length of the rod is exhausted. By certain simple tools which he employs, the nailor is enabled to give any desired shape to the nail, and to fashion one end of it into the form of a head. The celerity with which all this is effected almost surpasses belief. There was one occasion on which a nailor undertook to make seventeen thousand large nails in a week, for two weeks together; a feat which he successfully accomplished. A provincial journalist afterwards made the following calculations as to the muscular activity involved in the operation:—"Those who do not understand the nature of the work may form some idea of the undertaking when they are informed that the above quantity is allowed to be as much as three ordinary men can perform without difficulty; and that, allowing twenty-five strokes of the hammer (which is two pounds' weight) to each nail, including the cutting of the rods into a size convenient to be handled, and re-uniting them when too short, there were no less than 1,033,656 strokes required before the task could be completed. In addition to this, the workman had to give from one to three blasts with his bellows for every nail he made, had to supply the fire with fuel, and had to move from the fireplace to the place where the nails were made, and *vice versâ*, upwards of 42,830 times!"

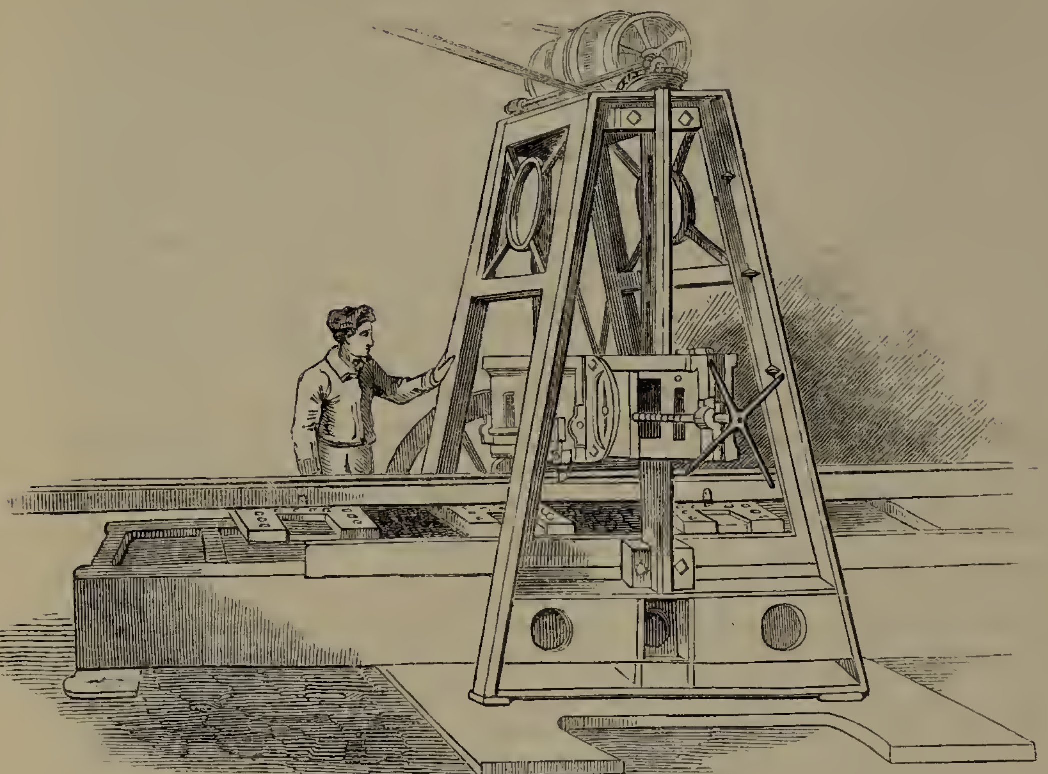
The kind called "cut" nails have less toughness and strength than wrought nails. The general system is to cut up sheets of iron into strips whose width equals the intended length of the nails, and then to cut up these strips into small pieces shaped properly for nails. For the first of these processes the sheet-iron is held by a man up against a large cutting machine acting like shears (Fig. 1041), one cut of which severs a strip from end to end; and by shifting the sheet of metal an inch or two at a time, the whole of it becomes by degrees cut up in a similar manner. Each strip is then taken up in turn, and held against another machine, which cuts it up into nails. Cut nails are generally pretty flat, and do not project much at the head; so that, by making oblique cuts, slanting alternately in opposite directions, a number of wedge-shaped nails are produced, without any waste of material. In some of the machines there is a vibratory motion so as to give this alternation of direction; while in others the strip of iron is turned over after each cut. In either case the strip is held by a boy or man, and its end pressed up against and between the blades of the putting-engine (Fig. 1042). In some forms of the machine the iron undergoes a pressure as well as a cutting, by which an approach is made towards the strength and toughness of wrought nails.

In the making of *screws* the iron is brought to the state of rod or wire before the screw-maker commences to work on it. The machinery by which the worm or thread, and also the head, of a screw are made, is very curious and ingenious. There are five successive stages in the making of a screw from a piece of iron-wire—viz. cutting off a piece of wire of proper length, forming a protuberant part for the head, shaping this head in a lathe, making the cut or dent in the head, and

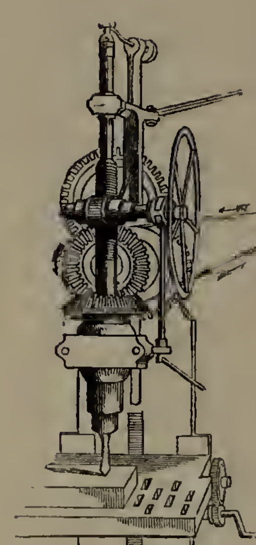
1044.—Ancient Swords and Daggers.



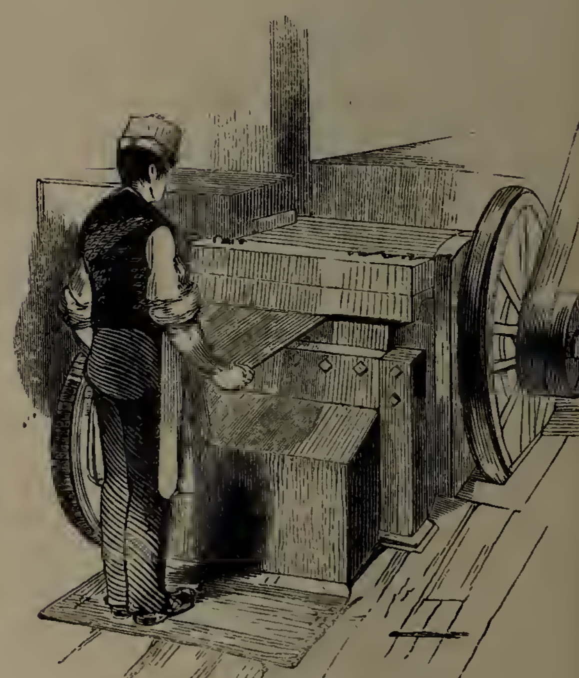
1042.—Making Cut-Nails.



1039.—Planing-machine.



1038.—Drilling-machine.

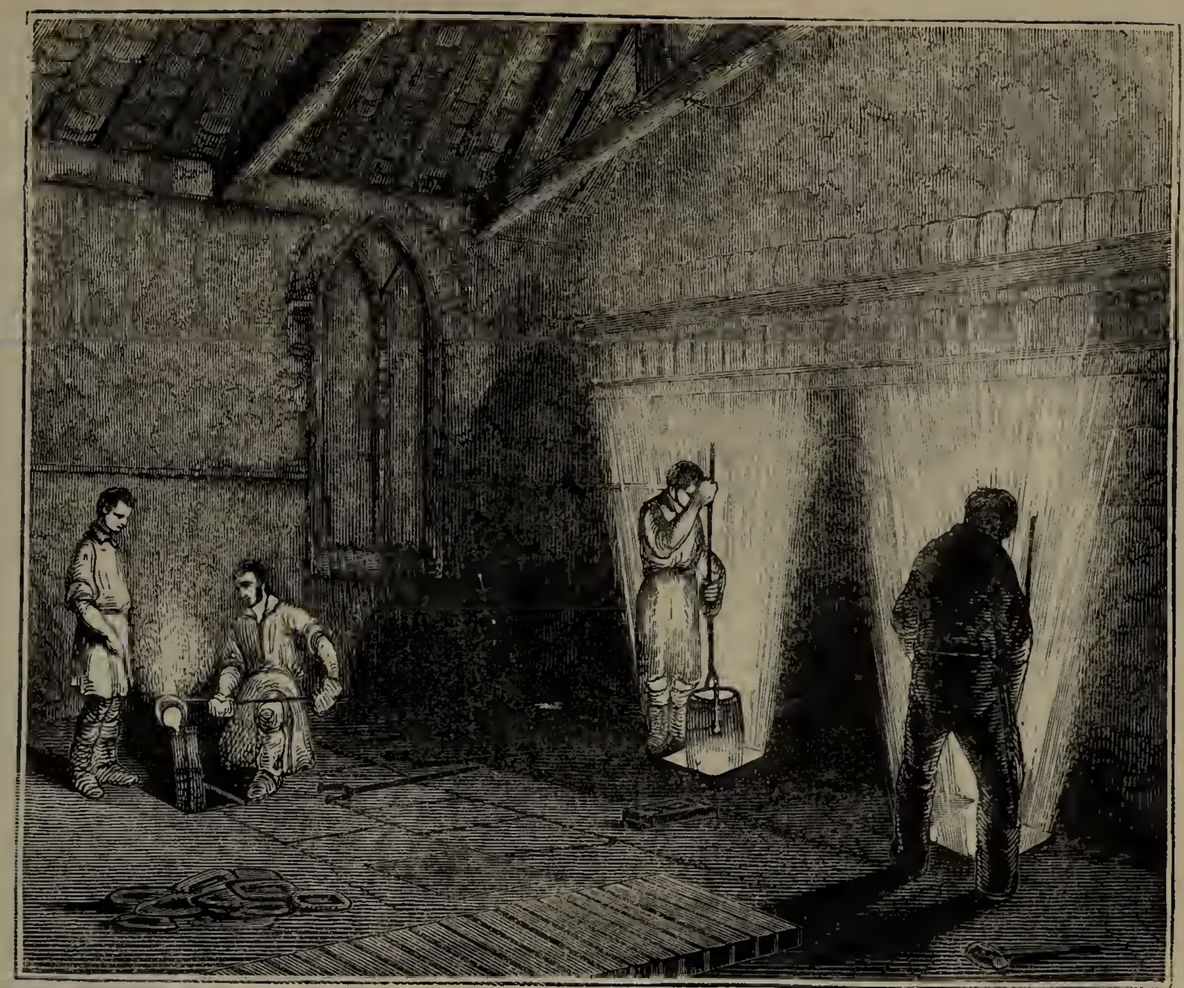


1041.—Cutting Sheets of Iron for Nails.

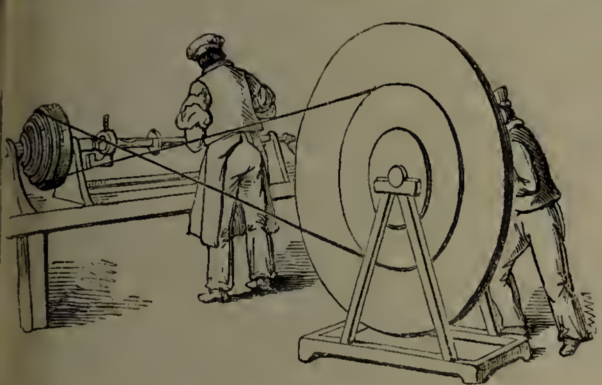
1040.—Wire-drawing Machines.

1043.—Making the Heads of Screws.

1050.—Forging Files.

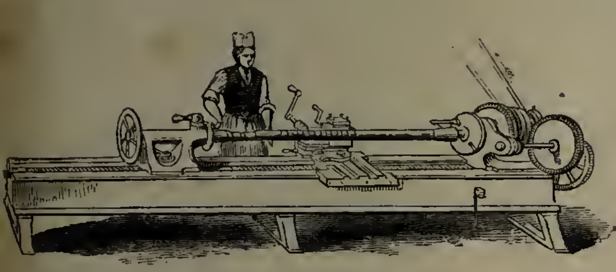


1049.—Steel-casting: Furnaces, Crucibles, Mould, Ingots, &c.



1045.—Lathe for Turning Iron.

1051.—File-cutters.



1047.—Screw-cutting Lathe.

1046.—Cutting the Thread or Worm of Screws.

1048.—Shear and Tilt Hammers: Steel-manufacture.

making the worm or thread. In some machines only one of these processes is carried on; while in others two or three of them are combined in a curious manner. In some the wire is simply cut up into pieces long enough for screws; after which each piece is taken up separately by a boy (Fig. 1043) and held against a machine which instantly compresses one end in such a way as to form a head. The heads of the screws are turned separately in a lathe, to give them a proper form and a smooth surface. They are further fixed vertically in a small machine of intricate and delicate construction, in which a circular cutter makes the groove or notch in the head. Lastly, they are fixed horizontally in a small lathe, where they are made to rotate rapidly while a woman (Fig. 1046) cuts the worm or thread on the surface, by means of a sharp steel cutting tool held in her hand. This process, like as is that of cutting screws of larger size, by the machine sketched in Fig. 1047, depends a good deal on the relation which subsists between two movements; the screw itself rotates on its own axis, while the cutting tool travels on from end to end of it by a distinct movement; and the cut thus made has a spiral direction given it, the obliquity or slope of which depends on the relative velocities of the two movements.

Many kinds of nails and screws, before being used, require to be annealed, as a means of giving them greater toughness: this is effected by heating them in ovens, and allowing them afterwards to cool very gradually.

Although we have here spoken of such kinds of wire, screws, and nails, as are made of iron, it will readily be understood that the same processes, modified slightly in details, are applicable to the use of other metals in these manufactures.

Conversion of Iron into Steel.

If we look around us among the objects of every-day life, we find iron in so many forms, that the manufactures connected with them might seem to be almost endless. And so indeed they are, when we take note of the subdivisions of employment which have gradually developed themselves; but in respect to the actual working of iron, those processes already described will illustrate the principle involved. There is, however, a very large and beautiful series of manufactures connected with the use of this metal in a more advanced state, viz., that of *steel*. It will be convenient, therefore, to see how the transformation from the one state to the other is effected; and then to notice a few of the practical applications of steel in the arts.

Steel, like cast-iron and wrought-iron, contains carbon; greater in quantity than is possessed by wrought-iron, and less than in cast-iron; but the difference between the three seems to depend more on the mode in which the carbon is combined with the metal than on the amount combined. Be this as it may, the process of steel-making, or the conversion of iron into steel, consists in causing carbon to enter into the substance of bar-iron, under the influence of great heat and peculiar arrangements. Any iron may be converted into steel; but it is a curious fact that, although England is so rich in iron, and so skilled in its manufacture, nearly all our best steel is made from bar-iron brought from Sweden. There is a particular mine near Upsala, in that country, which produces a kind of iron better fitted for making steel than any other known in other countries: to what circumstance it owes this superiority is still a matter of discussion; but the fact itself seems to be generally admitted; and the iron thence obtained commands a very high price. There is, however, a large amount of iron, from our own mines and from different foreign countries, annually converted into steel, principally at Sheffield; and the principle of the manufacture is the same, whatever iron be used.

The "converting-furnace" is the place where the iron begins to assume the form of steel. In this furnace is an oblong trough or cell, twenty feet long, three wide, and about three deep. On the bottom of this trough is placed a layer of coarsely-pounded charcoal; then a layer of the iron bars which are to be converted into steel; then another layer of charcoal; then another layer of bars; and so on until there are twenty or thirty of these alternations. The surface is then coated with a kind of clay; all openings are closed, and a fire is kindled in such a position that the flame and heated air may play around the trough without acting immediately on its contents. The effect of this confined heating is, that the carbon becomes absorbed into or combined with the iron, which thereby acquires a molecular character which it did not before possess. One of the bars is so placed in the furnace that a man can draw it out, and test the progress of the operation by the appearance which the bar presents. Steel for different purposes requires different degrees of this absorption of carbon; or, as it is termed, different degrees of "conversion;" and the "converter" therefore manages the furnace according to the kind of steel required to be produced. Coach-springs, knife-blades, files, razors, and steel for casting—each requires its own particular carbonization or conversion of the iron employed. When this process is ended, the iron has assumed a form which obtains for it the name of *blister-steel*, and in this state it has absorbed about one per cent. of carbon, which seems to act upon it in a way never yet thoroughly understood. The "conversion" is the employment of a distinct class of manufacturers at Sheffield, called "steel-converters;" and the "blister-steel" produced by them is afterwards submitted to other processes according to the purpose to which it is to be applied.

Scarcely any articles are made from blister-steel, for it is deficient in many of the qualities required in such a material; but after it has been hammered very heavily, it acquires an increased degree of toughness, and is then known as *common-steel*, which is employed for the cheaper kind of cutlery. A higher quality is that designated *shear-steel*, being such as is employed for shears and a large number of other cutting instruments. The process by which the steel is brought to this state, called "shearing," very much resembles the welding of iron, and depends on the intimate union of many bars of common steel into one. The "tilt-house," where this is conducted, is exposed to a greater amount of violent shaking than almost any other building devoted to manufactures; and it is impossible to walk through the town of Sheffield without hearing unmistakeable evidence of the vicinity of such a building. The "shearing" and the "tilting" of steel are different processes, but both require the use of enormous hammers, and both are frequently carried on in the same building.

In the "shearing" of steel, the bars of blister-steel are broken up into pieces about a foot long; each of which, after being heated in a furnace, is beaten out by a ponderous hammer to the length of about thirty inches. Next, five or six of these elongated pieces are fastened one upon another into a pile, heated to a white heat, and beaten on all sides until they thoroughly incorporate into one bar. Sometimes this "sheared" bar is broken in two, the two halves placed one on another and heated, and again hammered or welded into one. The degree to which this process is carried gives rise to the distinctions between "double-shear," "single-shear," and "half-shear," as applied to the quality of the steel produced. The steel so produced is much more dense and compact than "blister-steel;" and to make it yet more uniform in substance and texture, it undergoes the further process of "tilting." The bars of sheared steel are heated to a low temperature, placed upon smooth anvils, and beaten in every part for a long time by hammers weighing sometimes as much as 20 cwt. A man sits in a swing, by which he can oscillate to and fro, and bring every part of the bar in succession on the face of the anvil. Great closeness and beauty of structure are given to the steel by this powerful hammering. In Fig. 1048 many of these processes are shown: there is a furnace for heating the bars; three of the enormous tilt or shear-hammers; the anvils on which they act; the swings in which the "tilters" sit; and three blast-pipes which direct powerful currents of air to blow off loose dust from the faces of the anvils.

Perfect as tilted steel may appear to be, it is surpassed for many purposes by *cast-steel*—one of the greatest modern improvements in the steel manufacture. The steel, broken up into small fragments, is put into melting pots or crucibles made so as to bear a very intense heat. The melting-pot, at the time of filling it with steel, is at a white heat, and lies imbedded in a fiercely-burning fire in the kind of furnace called a "wind-furnace," the mouth of which is a hole in the floor of the cast-house. A lid is put on the filled vessel; coke is thrown on so as completely to bury it; the cover of the furnace is fitted down tightly, and the heat is then excited to the highest degree—a degree so intense that it is said nothing else known in the manufacturing arts, not even that of a glass furnace, can equal it. Here the melting-pot remains until the steel contained in it has become perfectly liquid, and glittering with a dazzling fiery whiteness. The office of pouring this liquid steel into moulds is almost fearfully interesting to a looker-on. In the first place the men employed cover their hands and legs with wetted pieces of sacking and leather, to shield them a little from the heat. The iron cover is removed from one of the furnaces, and amid the bright glare of light which immediately shoots up from the fiercely-burning materials beneath, a man is seen to hover over the fire, lower a kind of tongs into it, and draw up the crucible containing the liquid steel; another man lifts off the cover; a third removes the adhering slag or cinder from the surface; and the crucible is finally held in such a manner that the contents may be poured out into the mould, which is an oblong brass receptacle standing up endwise. The several stages of this perilous operation are sketched in Fig. 1049. How the human eyes can bear the light, and the bodies the heat, to which the steel-casters are exposed, is a marvel to all but themselves. While pouring the liquid steel into the ingot-mould, there is a profusion of delicate greenish sparks darting around in all directions; and instances have been known of the men losing their eye-sight by the effect of these sparks.

When the ingots of cast-steel, which weigh from about forty to a hundred pounds each, are cold, they are removed from the cast-house, to be applied to the various purposes for which cast-steel is used. The ingots are heated to a certain temperature, and passed between ponderous steel rollers, by which they are brought to the state either of bars or of sheets.

Manufacture of Files and Saws.

Here, then, we have traced the numerous and remarkable links in the chain of processes whereby crude iron is converted into the beautiful substance, cast-steel. A glance may next be taken at some of the practical employments of this steel in the arts.

Although a *file* may appear a very humble mechanical tool, yet it is one of the highest importance in manufactures. As a means of abrading or wearing down the surface of a piece of metal, to give it any desired form or an additional degree of smoothness, nothing else is at once so effectual and so portable as a file; the little serrations on its surface wear down the metal to which they are applied; and great skill is required in making these serrations or teeth with the necessary strength.

In this, as in almost all other varieties of the steel manufacture, the metal is *forged* in one part of the operations; by which is meant a heating in a forge-fire or on a hearth, and a hammering by means of heavy hammers on an anvil. For making files, bars of steel of the proper width and thickness are selected, and cut into file-lengths. Each of these is placed among the burning fuel of a forge-fire, and brought to a red heat. If the file be of large size, there are two men employed in making it, the "striker" and the "forger," who place themselves on the opposite sides of the anvil as in Fig. 1050; both are provided with hammers and a number of other small tools and implements, by which the red-hot piece of steel, held by pincers at one end, is quickly brought into the shape of a file, whether round, angular, or flat. When forged, the files or file-blanks require to be annealed, for the removal of the brittleness which they have acquired by the forging; this is effected, as in other examples of annealing, by heating the pieces of metal in a kiln or oven, and then allowing them to cool very gradually. After this, the surfaces of the pieces are ground on a large grindstone, by which they are brought level and tolerably smooth.

Up to this point the article produced is nothing more than a plain blank piece of steel; but it is now in a condition to receive the teeth or indentations which will convert it into a file. This is a very remarkable process, since it is one which has hitherto baffled all attempts to bring machinery to bear upon it. File-cutting machines have been invented from time to time, and brought partially into operation; yet in spite of the ingenuity shewn in their construction, they have failed in realising all the qualities required of them. Files are, therefore, still cut by hand, as they have been for ages. In this process the cutters sit in a row in front of a long bench (Fig. 1051) with their faces towards a range of windows. The steel-blank is strapped down to a block or support, where the workman can conveniently act upon it. He holds in his left hand a very tough and sharp piece of steel, the edge of which is fitted to cut the teeth of the file; while in his other hand he holds a hammer. He applies the cutting edge to the blank, and by one blow of the hammer cuts one of the teeth; the edge is then removed to a distance equal to the intended space between two of the teeth, and another blow is given; and so on from one end of the file to the other. It is quite surprising to see the accuracy with which these several cuts are made; the strict parallelism which exists among them, the equability of depth and of width, the exactness in the slope or sides of each cut—all these are points which require years of practice to attain; and if a file-cutter quits the employment for any considerable time together, his fingers are said to lose a certain delicacy of touch which is essential to the operation. Some files have teeth only in one direction, while some have two series, crossing each other at a given angle; some are flat on both surfaces, others round on both surfaces, and others again flat on one side and round on the other; some have teeth formed of fine lines, while others have deep notches or hollows; some have only eight or ten teeth to an inch, while others have upwards of twenty; but whatever may be these diversities, all are alike produced by the file-cutter, who cuts one tooth at one time, let the whole number of teeth in the file be what it may.

As the file-blank had been rendered soft before the cutting, it has now to be hardened again. It is heated in a forge or kiln, and when brought to a certain temperature, it is plunged into a tank (Fig. 1052) containing cold water, in which ale-grounds, salt, and other ingredients have been introduced: this gives a peculiar "temper" to the files, and enables them to bear the severe usage to which they are afterwards exposed. The files are then scrubbed clean with sand and water, and finally tested as to their soundness, by the clearness of the "ring" or vibration which they give when struck.

Another kind of mechanical tool, requiring quite as much care in its manufacture as files, is the *saw;* and this, like the former, is among the occupations which give life and activity to the town of Sheffield. Saws are made of three different kinds of material,—sheet-

iron, shear-steel, and cast-steel; but all those of the better quality are of the last mentioned kind, and will serve to exemplify the others.

Ingots of cast-steel are first rolled or milled into sheets having the proper thickness for saws; and these sheets are cut up into strips by means of some such machine as that sketched in Fig. 1058; which is, in fact, a pair of shears mounted on a frame. The cut edges are made smooth by applying them to a grindstone, and one of the edges is then provided with the teeth which give it the character of a saw. This is effected by a kind of punching. There is a small press, having a triangular punch at its lower extremity; a man holds the saw beneath it (Fig. 1059), and by the action of his right hand brings down the punch forcibly upon the surface of the steel, cutting out a little piece equal to the intended size of the teeth. He then shifts the saw a little, and makes a second tooth in a similar way; proceeding thus from end to end of the saw with great quickness. The size and form of the punch employed depend on the kind of tooth to be made, and vary greatly in different instances.

After the teeth are cut, the saws are "hardened," by being heated in a kiln or oven, and suddenly cooled by being plunged into a tank of oil. They are then slightly heated again, and while yet warm they are hammered at various parts, to remove any crookedness which the previous processes may have given them. Next they are "planished," that is, they are rested on a polished steel anvil, and hammered repeatedly over every part, by which the substance of the steel is made uniformly dense, even, and regular. Then ensues the "grinding" (Fig. 1053). This consists in attaching the saw to a flat board, and applying it to the edge of a grindstone, so as to grind off all asperities, and make the saw perfectly flat: the manner in which this is done is somewhat remarkable, since the workman seems to a bystander in imminent danger of being precipitated over the wheel, or of falling upon it while in rapid revolution.

Another hammering is required to remove the twisting occasioned by the grinding; another beating is given to restore the "temper;" and another (but very slight) grinding is given to remove the hammer marks. After which the "set" is given to the teeth; that is, the lateral bending which every tooth of a saw presents. Here a curious example is afforded of the accuracy of hand and eye which long practice can give. The workman rests the saw flat on a smooth steel anvil, and by means of a very small hammer held in his right hand, he gives a blow to every alternate tooth, thereby bending it out of the straight line. He then turns the saw over, and strikes all the other teeth, so that every alternate tooth may be bent in a different direction. Although he runs along the saw with his hammer, giving blows as fast as his hand can move, yet he rarely if ever hits two adjoining teeth in succession, but always misses as many as he hits.

Swords and Cutlery, in early times.

We can hardly fail to observe, that the most important use of steel is, and always has been, for the fabrication of cutting instruments of some kind or other. Files and saws are both of them cutting instruments, in a certain sense; but those implements which present a smoothness of edge are more properly designated by this name. The swords, daggers, knives, lancets, razors, scissors, and such like—these are the instruments in which the use of steel renders important services.

There seems to be pretty good evidence, that in almost all rude countries, cutting tools were made of bone, of flint, or of stone, before iron or steel tools were known. And the reason for this is plain enough; since the fashioning of a rude kind of knife out of a bone or a stone is simply a mechanical operation; whereas the possession of a piece of iron depends on a previous process of smelting. Most of our early navigators, in their accounts of the new islands and countries which they discovered, speak of the use of such cutting tools as are here alluded to. The New Zealanders, for example, have been accustomed to make saws and various kinds of tools of bone (Figs. 1062, 1064). At Pompeii has been found evidence of the use of swords and a kind of armour made of bone (Fig. 1061). Flint knives were often used among the ancient Egyptians (Fig. 1065); and many other countries present specimens of a similar kind.

With regard to the knives and other cutting instruments made and used by the nations of the East in past times, Dr. Kitto, in the notes to the 'Pictorial Bible,' observes:—"They (*i.e.*, swords, knives, and cutting instruments generally) were successively, and afterwards simultaneously, of flint, bone, copper, iron, and steel. Probably at first a single knife or dagger, worn in the girdle, was made to serve all general purposes. Indeed, at present in the East, almost every one wears a dagger in his girdle, from the noble to the shopkeeper and husbandman; and although ostensibly a military ornament, it is rarely drawn for any more formidable duty than that which usually devolves upon a knife—from the slaughter of a sheep to the cutting of a string, or the scraping of a shoe. Homer's heroes kill their sacrifices with knives or poniards, which they wear by the side of their swords. In process of time, however, knives became scarcely less diversified in form and adaptation to particular uses than those which the shop of an English cutler exhibits. In sacrifices alone, three or four different knives were used—one for killing the victim, shaped like a poniard; another sharp, but rounded at the top to the fourth of a circle, for flaying; and a third, stronger than these, and of a cleaver shape, for dissecting the carcase. There were also pruning-knives, carving-knives, and hunting-knives. Some had the hafts worked out of the same piece as the blade, and others had handles of horn, bone, or wood. The wood-cut (Fig. 1054) represents an assortment of cutting and stabbing instruments, selected from various ancient Egyptian sculptures, and such as were probably known and used by the Jews; particularly as in such articles there is, in however different times and countries, much analogy in general appearance. The 'knives and lancets' used by the priests of Baal were doubtless such as they employed in their sacrifices, and to which we have particularly adverted."

The swords and daggers of early times, and of Oriental countries at the present day, show frequently a good deal of richness and beauty of appearance, thereby indicating, that whatever might be the state of the other manufacturing arts at the time, the possession of a good sword was deemed a matter of much importance; while the knives for domestic use were of a very different character. In Fig. 1037 we have a sketch of some rude ancient Egyptian knives; in Fig. 1044 a group of ancient swords and daggers; in Fig. 1054 the knives and daggers alluded to by Dr. Kitto; in Fig. 1056 a group of swords and halberts of the time of Henry VII., which will afford means for comparison with the productions of earlier times; in Fig. 1060 a group of modern Oriental swords and daggers; and in Fig. 1066 a group of ancient Persian swords and daggers.

There have been some curious features connected with the sword manufacture in early times. The Damascus blades, and the Toledo blades, have each in its own particular sphere acquired great fame for their excellence: the keenness of the edge and the extensive and perfect elasticity having been carried in them to the utmost point. We have all read of Orientals wearing their swords twisted round their waists, or even coiled up in their turbans, so great was their elasticity; and swords have been made so keen as to cut a silk shawl in two, while resting lightly on the edge. Such, at least, have been the reported wonders; but the Easterns may probably in this, as in many other matters, embellish their stories a little.

One circumstance, however, is undoubted; viz., the existence in the ancient Damascus sword-blades of a wavy figured design, called "damask," or "damascene," from the name of the city. It is supposed that this was produced by some peculiar mode of combining different pieces of steel in the manufacture, though nothing certain is known in the matter. Some years ago a French experimenter, M. Clouet, made some swords which bore a very near resemblance to those of Damascus in this respect. He proceeded as follows:—The blade was composed of a number of thin plates of different varieties of steel, united together in the direction of their length by forging and welding; the surfaces of this compound bar were then worked upon with a graving tool, so as to produce a variety of hollows, which were afterwards worked up and brought nearly to a level with the faces of the blade; by this means an imitation was produced of a peculiar kind of tresses or curled lines seen in the Damascus blades. A further imitation of a sort of fleckiness in those blades was produced by M. Clouet, by welding together a number of steel rods, twisting them at a red heat, forging and twisting them several times in succession, straightening the compound bar, slitting it through the middle, and welding the two outer sides together, so as to render visible the grain which had before been in the heart of the bar. M. Bréant, another experimenter, sought to imitate a peculiar appearance which the Damascus blades present by mixing up a good deal of carbon with the steel from which the sword-blades were made.

Independent of this little-understood peculiarity in the Damascus blades, there has been in many countries a process adopted of inlaying sword-blades, as a means of decoration; this, too, has obtained the name of "damasking." Sometimes figures are produced in relief by cutting the steel; at other times the surface is engraved; and at others small pieces of metal are inlaid like mosaic in the surface of the steel. In one form of inlaying, the surface of the steel is cut into rather deeply, and thick gold or silver wire is beaten in so as to fill up the channels. In another, the steel is heated, and then hatched over with a knife; the design is drawn on the hatching with a metal point, and fine gold wire is let into the hatches at the lines of the device. Benvenuto Cellini, in his autobiography, speaks of his great desire to learn this art; he describes the damasking of the Turkish scimitars, and proceeds to say:—"The Lombards make the most beautiful wreaths, representing ivy and vine leaves, and others of the same kind, with agreeable turnings, highly pleasing to the eye. The Romans and Tuscans have a much better notion in this respect; for they represent Acanthus leaves with all their festoons and flowers winding in a variety of forms; and among these leaves they insert birds and animals of several sorts with great ingenuity and elegance in the arrangement."

The city of Toledo, in Spain, has been long famous for the production of sword-blades—one of the few branches of manufacture brought to anything like perfection in that unhappy country. The author of 'A Year in Spain' makes the following remarks concerning a royal sword-manufactory still carried on at Toledo:—"Here are made all the swords, halberds, and lances required for the royal armies. The establishment is on an admirable footing; and the weapons now made in it are said to be nowise inferior to those famous *Toledanos* which, in more chivalrous times, were the indispensable weapons of every well-appointed cavalier. Toledo was not only celebrated in the time of the Moors, but even under the Romans, for the admirable temper of its swords, which is chiefly attributed to some favourable quality in the water of the Tagus used in tempering the steel. As a proof that this is the case, one of the workmen told me that in the earlier period of the French invasion the manufactory was removed to Seville, where the national junta then was; but the swords manufactured on the banks of the Guadalquivir were found to be very inferior to those which the workmen had made in Toledo."

Manufacture of Cutlery.

Whatever may be the form assumed by any of the varieties of cutlery in the present day, they are all produced pretty much in the same way, so far as regards the routine of processes. Heating, hammering or forging, grinding, tempering, whetting, polishing—all modified in various ways according to circumstances, are employed in the conversion of a piece of bar-steel into a cutting instrument. A few examples may here be given to illustrate them all.

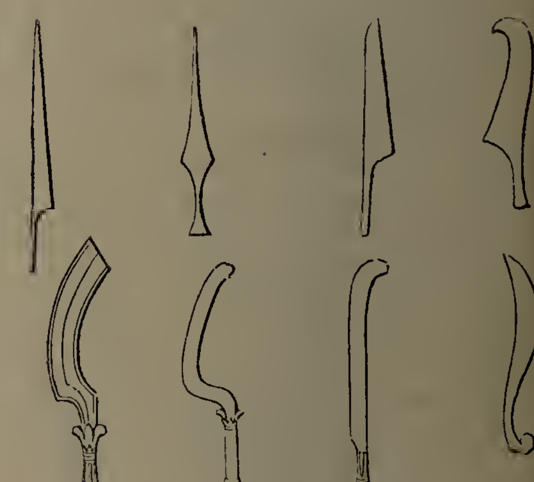
Let us begin with *swords*. The steel for making swords is brought to the factories in the form of "sword-moulds;" that is, pieces fitted to make one sword each. One of these bars is heated to a certain temperature, and hammered into form by two men, one of whom does the hardest work, and the other superintends the operations. When the sword requires to have a concavity or hollow given to the surfaces, it is hammered between steel projections or knobs, called "bosses." When the general form is given to it, the sword is hardened and tempered, by processes similar to those we have before described. It is then straightened and adjusted, next ground upon a large grindstone, then tempered again, and afterwards polished.

The making of knives presents, on a smaller scale, a nearly similar series of operations. The form and decoration of a knife, however, lead to many peculiarities. At Sheffield the principal cutlers possess exquisite specimens of this kind of cutlery. Sometimes a knife, not larger than the thumb nail, will have a dozen or twenty blades, all perfectly formed and exquisitely polished. The writer has seen a knife only an inch long when closed, with seventy blades, all made in a beautiful manner, and illustrating nearly all the shapes ever given to knife-blades. Another specimen has two hundred and twenty blades, all of which are exquisitely etched on the steel with portraits, landscapes, and other subjects. A third consists of a knife having eighteen hundred and forty blades! all provided with hinges and springs, and all closing into one handle. Foreign countries occasionally furnish curious specimens of cutlery. Fig. 1055, for example, gives a sketch of a "musical knife" deposited in the Louvre. Of this knife it is said ('Penny Magazine,' No. 578), "This very curious specimen of ancient musical taste is to be found among the miscellaneous collection of early French antiquities preserved in the Louvre. The blade of the knife is of steel, upon which is engraved the 'Blessing of the Table,' or Grace before Meat, which may be literally translated thus—'What we are about to take, may Trinity in Unity bless. Amen.' This is accompanied by the musical notes of the *bass* part only, so that there must have been a set of four or five knives, upon each of which the other parts necessary to make the composition complete were engraved. From the character of the musical notes, and the general appearance of the ornamental work that embellishes it, we should be inclined to fix the date of this knife somewhere about the latter half of the sixteenth century, when a taste for music was so universally felt, and its practical study so commonly exercised, that nearly every person with any pretension to respectability or a good education could play on some instrument, or at least bear a part in a madrigal or other composition. Not to be able to do so would imply the disgrace of ignorance, or a culpable neglect of the necessary accomplishments of good society. This relic is a curious confirmation of this fact. We may just remark in conclusion, that the ornamental portion of the blade is (like Mrs. Quickly's goblet) 'parcel-gilt,' that is, gilt on the raised parts of the work. The handle is of ivory, upon which is carved a running sprig."

1053.—Saw-grinding.

1052.—Tempering Files.

1055.—Musical Knife, in the Museum at the Louvre.



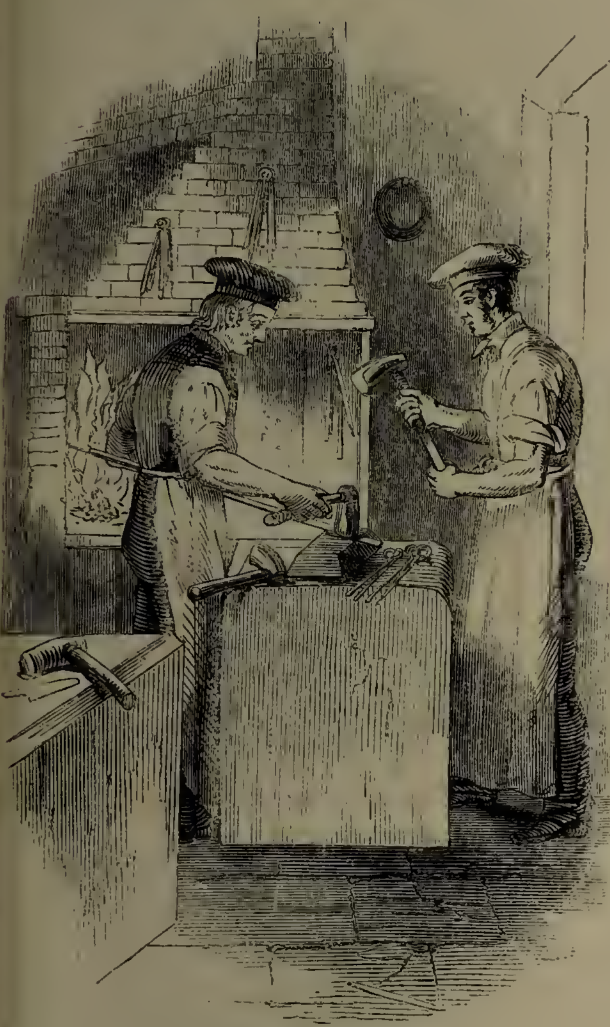
1054.—Ancient Egyptian Knives and Lancets.

1056.—Swords and Halberts, time of Henry VII.

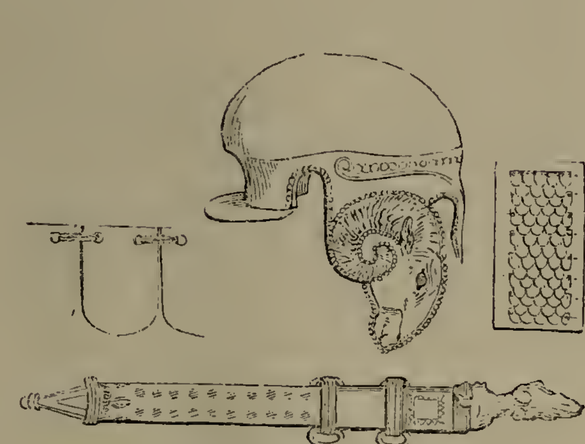
1057.—Cutting Ivory for Knife-handles.

1058.—Cutting Sheet Steel for Saws.

1060.—Modern Oriental Swords and Daggers.

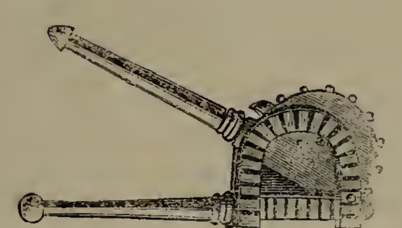


1057.—Forging Razor-blades.



1061.—Bone Sword and Armour, from Pompeii.

1062.—New Zealand Tools, made of Bone.

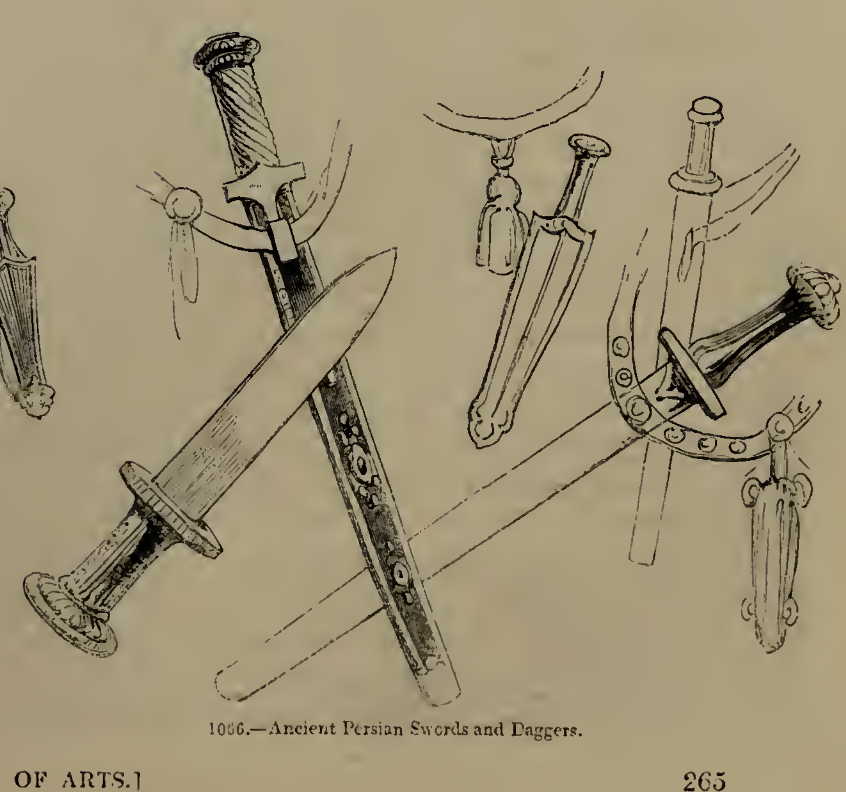


1063.—Ancient Egyptian Snuffers.

1064.—New Zealand Saw, made of Bone.

1059.—Cutting Teeth of a Saw.

1065.—Ancient Egyptian Flint-Knives.



1066.—Ancient Persian Swords and Daggers.

A table-knife, as made in modern factories, is forged out of a piece of bar-steel—"shear" steel for those of moderate quality, but "cast" steel for the best. A piece is cut off, long enough for one knife; and this is placed on the forge-fire until it has attained a red-heat. It is then taken out with a kind of tongs, placed upon the anvil, and there hammered till it assumes a form something like that of a knife-blade. The "tang," or that part which enters the handle, is made separately; or rather, the rudely formed blade is welded to the end of a small rod of iron, and the iron is forged so as to form the tang and also the shoulder between the tang and the blade. The whole is again heated, and hammered all over to complete the shape; the rusty-looking blade is then heated red-hot, next plunged into cold water to harden it, and then heated very gradually to a particular temperature, as a means of tempering it. Being thus brought to something like the appearance of a knife, the blade is taken to the grinding-wheel, where it is ground in every part to give shape to the outline, regularity to the surface, and the first semblance of a sharp edge; the grindstone employed is three or four feet in diameter, and is formed of a roughish kind of stone; after the use of which the blade is ground on a smoother stone, called the "whitening-stone." After this "grinding" and "whitening," the blade is "glazed" or "polished"—a process, like the other two, effected by means of wheels, but of a very different kind. The "glazing" wheel is a circular piece of wood fixed upon an iron axis, and coated on the edge with leather; the leather is lightly touched, first with a solution of glue, and then with emery-powder, by the friction against which the blade of the knife becomes polished to a very high degree, and it is then fitted for insertion in its handle. If we look at the grindstone represented in Fig. 1076, we shall see that the Egyptian cutlers have a very rude and inefficient way of setting the wheel in motion; the foot being employed for this purpose, instead of the more complete mechanical arrangements of English factories. But in truth this is only one among many examples of clumsy mechanism in Oriental countries.

The making of *razors* differs from that of table-knives, mainly in the greater degree of care required and bestowed. The bar of steel is not cut off to the length for a razor, but one end of the bar is placed in the fire to be heated, and it is then held by a man at the other end, so that the heated part may rest upon the anvil (Fig. 1067); and the two men, the "striker" and the "forger," standing on the opposite sides of the anvil, speedily hammer the heated end of the steel into the form of a razor-blade, which is cut off from the rest of the bar, and carried through the subsequent processes nearly in the same way as the knife-blades, but with greater care.

One of the most particular points in razor-making is the determination of the proper heat to which to bring the metal in "tempering." If made too hard, the edge becomes too brittle for convenient use; if not hard enough, the edge cannot be made fine and keen; so that the point is to find a proper medium between two extremes. The cutlers generally determine this matter by the colour which the steel attains in the fire; each kind of cutting instrument requiring its own particular colour or oxidation. The temperatures connected with these colours are said to be nearly as follows:—

Fahr.	Colour.	Cutlery.
600°	Blackish blue	Springs.
560	Blue	
550	Bright blue	Pocket-knives.
530	Purple	Table-knives.
510	Brown, with purple spots	Scissors.
490	Brown	
470	Yellow	Pen-knives.
450	Pale straw	Razors, lancets.
430	Slight yellow	

The making of *scissors* differs very little from that of knives. Each half may be looked upon as one blade, and is forged out of a narrow bar of steel. The anvil of the scissor-forger is provided with a number of little projections, hollows, and appendages, by the aid of which the proper shape is given to the various parts of the blade. To produce the hoop or handle, a hole is first punched through the steel, and this hole is gradually enlarged by the insertion of instruments into it while hot. In the very cheapest kinds of scissors, each blade is cast in a mould, so as to save the trouble of forging; in large scissors, of better quality, the bulk of the instrument is made of iron, but the face of the blade consists of steel; in smaller scissors of the better kind, the whole substance is of steel. The grinding and polishing of the scissor-blades are effected as for knife-blades, and to these succeed the riveting of the two blades of each pair.

Pen and pocket knives, or those which clasp into a handle, are smaller specimens of the same kind of work as that which produces table-knives; but the arrangements for adjusting them in their handles are far more minute and intricate than in other cases. So many are the little bits of iron, steel, brass, and other materials employed in making a clasp-knife of average character, that every knife passes through the workman's hands nearly a hundred times, during the operation of putting all the various parts together: this is independent of the forging, and consists of a species of bench-work, in which small hammers, pincers, files, drills, gauges, polishing-wheels, and burnishers are employed.

The making of the *handles* for cutlery, though not exactly a branch of manufactures in metal, is so closely connected with it as to form a large and important feature at Sheffield. The materials of which these handles are made are very various: pearl, ivory, ebony, bone, horn, hard wood—all are used for this purpose, under a great diversity of form. Each kind of material is the subject of a particular department of labour. In the working of ivory for handles, as an example, the elephants' tusks are cut up into pieces of a convenient size, by means of a small circular saw working very rapidly (Fig. 1057), and these pieces are afterwards shaped by other instruments, bored or drilled to form a receptacle for the tang of the knife or razor, and polished on the surface. Many kinds of hard wood are treated in a similar way. Pearl, or rather mother-of-pearl, is, from its exceeding hardness, somewhat more difficult to work; and as it is seldom used to form the substance of any article, it is cut up into thin veneers or slices, which are placed as an external ornament to some plainer and cheaper material. Horn, from its peculiar character, is worked up into handles in a very different way: when heated, it becomes soft enough to conform to the shape of a heated iron mould, by the aid of great pressure; and it is by such means that the handles of numerous articles, such as umbrellas, &c., are made.

If we were to go through the range of the steel-manufacture, with its interminable variety of articles, we should find that forging, in some such way as has been here described, and casting in moulds made of fine sand, are the main processes whereby they are produced. Snuffers, fenders, fire-furniture, tools, chisels, instruments and implements of innumerable kinds—all are produced in some such way as the above. To what extent this art was practised in early times it would be difficult to say; but if the sketch given in Fig. 1063, copied from an ancient Egyptian painting, is to be construed as representing a steel pair of snuffers, it indicates an advanced state of the art somewhat beyond the point which we might imagine.

Needle Manufacture.

There is one other department of steel-manufacture so remarkable, that we must pay a little attention to it separately, before proceeding to other metals, viz. *needles*. These little adjuncts to the work-table are made in such immense quantities, and require such a high degree of skill in their manufacture, and such an extensive range of processes, that their importance is much greater than might at first be supposed. It has been estimated that at the village of Redditch in Worcestershire, which is the centre of the needle-trade, and nearly the whole of the inhabitants of which depend more or less on the manufacture, the number of needles made every week amounts to about seventy millions! Where they all go to, the sempstresses must determine; but it certainly seems remarkable that there should be made, at one place only, four times as many needles every week as there are inhabitants in Great Britain; but we may reasonably conclude that a considerable quantity is exported.

Needles are made of fine steel-wire, brought to that state by the wire-drawers of Birmingham or Sheffield. It is brought to the needle-factories in coils or hoops weighing about twelve or fourteen pounds each, the length of wire in each coil depending on the thickness. The needles commonly made vary from $\frac{1}{22}$ of an inch in thickness, designated No. 1, to $\frac{1}{100}$ of an inch, designated No. 12; for a medium between these two, say No. 6, the coil of wire is about two feet diameter, it weighs thirteen pounds, and the wire contained in it (about a mile and a quarter in length) will make about forty thousand needles.

The coils of wire are unwound, and by means of a stout pair of shears are cut up into a number of separate pieces, each about three inches long. As all these pieces have conformed to the general bend of the coil, they are curved or crooked; and this crookedness is forthwith removed in a very remarkable way. The little pieces of wire are grouped into bundles, which are placed within two iron rings or hoops placed a small distance apart; they are heated in an oven, and when brought to a particular temperature, they are taken out, and placed with the edges of the iron rings on a flat iron plate. A man then takes a pronged instrument, which he rests on the needles, and rolls the rings backwards and forwards (Fig. 1072); by which action all the pieces of wire are made to roll repeatedly one over another, so that they mutually correct each other, and all are brought to a straight form. The pieces are of a length to make two needles each; and each one, in the next stage of the operation, is sharpened at both ends, to give the first semblance of points for the two needles. This pointing is a very sad occupation, for the particles of steel worn off float about the air of the room, and get into the lungs of the workmen. The needle-pointer sits behind a small grindstone which is revolving very rapidly, and applies the needles to the surface of the stone (Fig. 1071). The workman takes fifty or a hundred wires into his hand at once, and applies them to the edge of the stone in such a peculiar manner, that he makes every wire separately rotate on its axis, and grinds away the ends of the whole hundred at once: it is one of the most surprising manipulations presented in the arts, for he will give true and symmetrical points to ten thousand needles in an hour! The room is generally rather dark, but a vivid stream of sparks shoots off from the stone. The grinder wraps a handkerchief over his mouth, to prevent as far as he can the inhalation of the steel-dust; but they are a reckless class of men, who have refused to adopt many precautions which the humanity of others has pointed out to them; and they continue to be, what they have ever been, a short-lived race, seldom surviving the age of thirty-five or forty.

In the next stage of progress, two holes are made near each other in the middle of the wire, to form the eyes of the two needles. There is a stamping-machine (Fig. 1069), consisting of a heavy hammer, at the lower surface of which is a die to give one half of the stamp or impress to the wire; while beneath is a block containing a die to give the other half of the same. The workman holds several wires between his fingers at once; drops one at a time on the lower die, and lets the hammer with the other die fall heavily upon it, which he is enabled to do by a string acted upon by his foot. The dies do not pierce two holes completely through the wire, but cut sufficiently deep to mark the size and form of the holes; and at the same time they form the channel or gutter which every needle exhibits near the eye. A boy next takes up a number of these partly pierced wires, spreads them out like a fan, and brings them one by one down upon a smooth steel surface, where two hardened and polished steel piercers descend, and drill the holes completely through. A part of the apparatus for doing this is shown in Fig. 1075, where *b b* represents the wire, *a* the block on which it is placed, *d* an apparatus for adjusting the wire to its place, and *c* the two steel piercers which descend to make the holes in the wire.

The wires are then "spitted;" that is, they are taken up by children, and threaded or spitted upon two smaller wires, which are made to pass through both the eyes of every larger one, in the manner shown in Fig. 1073. The stamping has occasioned a "bur" or protuberance near the eyes of each wire, and this bur is next filed down by a workman. These successive changes and processes may perhaps be better appreciated by a glance at Fig. 1070; where the left-hand specimen is the wire for two needles, as uncoiled from the hoop; and the others represent it, in succession, when straightened, when pointed at both ends, when stamped, when the eyes have been pierced through, and when the bur has been filed off. The form of the eyes and channels is better shown in the three magnified representations.

The wire still continues double; that is, it is long enough to form two needles; but by a dexterous bending of the "comb" of wires, each one is broken into two, the separation being effected between the two eyes of each wire. The "stamping," "piercing," "filing," "spitting," and "breaking," have had the effect of bending the wires in some degree; and to restore the proper degree of straightness is the object of the process of "soft-straightening." This process is undertaken by females, each of whom sits at a bench (Fig. 1068), spreads out the needles on a flat iron plate, and rubs them very quickly with a bar whose lower surface is convex. Although the needles are rubbed one by one, yet the process is conducted so rapidly that three thousand are straightened by one person in an hour.

The needles are next placed on flat iron trays, and deposited in an oven, where they are brought to a certain temperature; they are then quenched in oil or cold water; and tempered by being slowly heated to a very exactly determined temperature. After this, every needle which may have been slightly bent by the heating is straightened while cold by a few blows from a very small hammer; and the whole are then ready for the process of "scouring." This is one of the very few departments of the needle manufacture in which machinery is employed. The needles are laid out parallel on a piece of canvas, to the number of twenty or thirty thousand; they are coated slightly with emery and oil, and wrapped up in the canvas to the form of a roll ten feet long by about two inches in diameter. Two such rolls are placed on a long slab or stone, and an upper slab is made to roll over them to and fro, very much in the same way as a mangle. For six or eight hours together this rolling is continued, by which all the needles are made to rub against and rotate amongst each other, mutually polishing their surfaces by the aid of the emery and oil mixed up among them. The canvas parcels are then taken out and opened, the needles removed and washed in suds, replaced in new pieces of canvas, retouched with emery and oil, and re-scoured for another period of several hours. For the finest and best needles this process of scouring is deemed of so much importance, that the

whole mass undergoes five or six different scourings of eight hours' duration each.

After the scouring the needles go through a number of minor processes. They are shaken in a tray, to bring them all into parallel arrangement. They are spread out on a table before a number of children, who with great dexterity separate them into two parcels, one having the heads towards the right, and the others the heads towards the left. They are examined one by one, for the removal of such as may have been broken or injured in the scouring; a number which is said to amount to as many as sixteen or twenty in a hundred. They are applied to a very fine drilling-machine, by which the eye has a smoothness and roundness imparted to its edges, as a means of preventing it from cutting the thread. They are "ground" at and about the heads by being applied to the edges of small grit-stone wheels in rapid revolution; after which they are similarly applied to the edges of "polishing" wheels, which are made of wood covered with leather, to the surface of which a little polishing paste is applied. So far as these minute shades of difference can be shown in a woodcut, they may be illustrated in Fig. 1074; where *a* represents a needle with the eye and head rough; *b*, the head filed and brought to the proper form; *c*, the eye when "countersunk" and prepared for the last stage; *d*, the eye drilled and finished.

Such, then, are the numerous stages through which these tiny implements of steel pass, in their progress towards a manufactured state; and there are few other departments of productive art which show more strikingly the commercial importance to which even the most trifling articles arise when the demand and consumption of them are large.

MANUFACTURES IN COPPER, TIN, LEAD, AND THEIR ALLOYS.

IRON, in its original state, and in its modified form of steel, is so much more important in the arts than any other metal, that we shall be able to pass much more rapidly over the others; glancing chiefly at such points as differ in principle from those observable in the iron manufacture.

Copper is a remarkable metal in this respect, that—unlike iron—it is not only used in the single or uncombined state, but it forms a component element in a large number of alloys or mixed metals. Brass, for instance, is a compound of copper and zinc; "Prince Rupert's metal" (as it is called) is also composed of copper and zinc, but with less copper than the former; *bronze* consists of copper and tin, with a small quantity of some other metal added; bell-metal, gun-metal, tutenag, pinchbeck, Dutch metal—all are alloys, containing copper as one of the constituents.

Copper Smelting and Working.

This metal occurs in combination with various ores in the copper-mines; but the kind most usually found in Cornwall, where the chief supply is obtained, is "copper pyrites," a mixture of copper, iron, and sulphur. When dug out of the Cornish mines, the pyrites is carried over into Wales, where the chief smelting-works are situated near Swansea. There are different kinds of furnaces for effecting different parts of the operation; the chief of which are as follows:—The ore is first spread out over the brick floor of a calcining furnace, where it is exposed for twelve hours to a considerable heat; during which the sulphur and other earthy matters are driven off, and the copper and iron become oxidized, with a black colour and a powdery texture. The ore is drawn out from this furnace and thrown into a "smelting-furnace" of different construction: the object now in view is to melt the ore by a higher degree of heat; and when this is effected the liquid mass is stirred, to allow a further separation of the metal from the adhering impurities; the impurities are skimmed off as fast as they arise, and new charges of ore thrown on until at length there is a considerable quantity of liquid metal in the furnace. This is tapped or drawn off, and allowed to fall into a pool or cistern of water, by which the metal becomes "granulated," or divided into small grains of what is now designated "coarse metal."

The coarse metal consists of copper, iron, and sulphur; but it is richer in copper than the original ore had been; for whereas the ore contained only about one-twelfth part copper, the coarse metal contains about one quarter, on account of a good deal of the sulphur, iron, and other matters having been driven off during the calcining and melting. To purify the copper still further is the object of the next following processes in the series. The "coarse metal" is calcined nearly in the same way as the ore had been, but for a longer period: the iron becomes further oxidized by this process; and the mixture obtains the name of "calcined coarse metal." This is melted in a melting-furnace, by which sulphurous acid gas is given off, thereby getting rid of more of the sulphur and oxygen. It then becomes "fine metal;" and this fine metal, by process of calcining and melting, very similar to the former, becomes "coarse copper," which contains only ten or twenty per cent. of iron and other impurities; the pure copper amounting to eighty or ninety per cent. of the entire weight. The pigs of coarse copper are thrown into a "roasting-furnace," where they are heated with access of air, and afterwards melted. The melted metal resulting from this process is called "blistered copper;" and by a further heating, and careful management, it is brought to the state of "refined copper," in which all the impurities are finally got rid of. The complication of this series of processes arises from the difficulty of separating the copper from the other matters with which it is combined in the ore.

The refined copper is laded out of the furnace, and poured into flat moulds, which give it the form of cakes, about eighteen inches long by twelve wide. It is from these cakes that nearly all manufactured articles of copper must spring. The cakes are brought into the form of sheets by rolling. In the first place they are heated in small receptacles called "muffles;" and when at a bright red heat they are passed between cast-iron rollers, by which they become elongated; the rollers are brought gradually nearer and nearer together, so that by the time the cake has passed several times between them it has increased its length five-fold, and diminished its thickness proportionably. Being then too cold for further rolling, each cake is cut by strong shears into square pieces called "blanks," and these blanks, when again heated, are further rolled to a less thickness. This heating and rolling continue until the copper is brought to the state of sheet, having any required thickness; and it is then (after the removal of an oxide from the surface by means of an acid) in a fit state to be applied to manufacturing purposes.

The copper is brought from the state of ore to that of cakes at the large smelting-works in South Wales; but the further transformation of the metal into sheets is carried on at the copper-mills which are situated in various parts of the country. The working-up of sheet copper into various useful articles devolves upon different classes of workmen, according to circumstances. For boilers of steam-engines, the sheets of copper are cut up and riveted pretty nearly in the same way as sheet-iron. For the sheathing of ships the copper is brought in the form of sheets in definite size, and these are nailed on to the ship's bottom by copper nails. For a variety of articles the copper requires to be cast in sand-moulds; and in such case cake-copper, to which cuttings and scraps are possibly added, may be used, since it is not necessary to bring the copper first to the state of sheets.

The greater number of articles made of copper depend on the labours of the "copper-smith," by whom sheet-copper is cut, hammered, riveted, soldered, made into pipes, and otherwise worked up into useable form. Many of the vessels made of copper, especially those for sugar-refiners and distillers, are often of very large size, requiring the junction of a great number of sheets of copper. Fig. 1077 correctly represents the comparative sizes of some of these. Sometimes sheets of copper are hammered into a circular or cylindrical form. Sometimes a piece of copper is cast in a mould to the form of a double convex lens; and this lens, by being heavily hammered in the middle, is made to spread out in such a manner as to form a concave dish, such as would form the lower half of a sugar-pan in a refinery. Occasionally, copper pipes are made, by cutting up the sheets into strips, coiling up these strips into something like a cylindrical shape, drawing this cylinder through a hole which will perfect its form, and finally soldering the meeting edges so as to form an air and water tight tube. From such a tube as this are made the "worms" or spiral steam-pipes which supply heat to sugar-pans, the tube being bent round into a coil shaped so as to fit round the interior of the vessel. Many articles are made by riveting instead of soldering; in which case the holes are bored by some kind of punch, and the rivets driven in by hammers. One of the most singular processes (in its effect upon the ear) in this series is that of "planishing;" this, as in other branches of metal manufacture, implies a careful hammering, intended to give closeness, density, and uniformity to every part of the metal, by closing the pores and levelling all irregularities. It is at all times a noisy operation, but with so sonorous a metal as copper it produces a rough music which few untutored ears can bear with patience.

Bells and Bell-making.

From copper, simply as such, we pass to some of the alloys of which it forms a component ingredient; and, of these, few are more interesting than *bells*, for these have given rise to a host of pleasant allusions and similes by the writers of every nation where they have been customarily used. Schiller wrote a "Song of the Bell," which is one of the most vigorous and spirit-stirring productions ever devoted to manufacture; for, among other matters, the chief steps in the manufacture are treated by the poet. In many parts of Germany, especially near the Hartz Mountains, the casting of a large bell is made a matter of rejoicing, to which friends and neighbours are invited by the bell-founder; and it seems to be as a sort of joyous account of one of these meetings that Schiller wrote his song. The mixing of the ingredients, the melting, the casting, the cooling—all are described; and at intervals or resting-moments between the processes the poet indulges in reflections upon the many events of life connected in one way or other with the sound of a bell. One of his stanzas relates to the supply of the furnace:—

> "Billet of the fir-wood take,
> Every billet dry and sound,
> That flame, a gather'd flame awake,
> And vault with fire the furnace round.
> Quickly cast the copper in,
> Quickly cast due weight o' tin,
> That the bell's tenacious food
> May rightly flow in order'd mood."

In another stanza we trace the melting and purifying of the ingredients:—

> "Ha! the rising bubbles tell
> Metals mingling, melting well.
> Salt of ashes lightly throw—
> So the fused ore shall flow.
> Quickly from the scum and froth
> Cleanse away the whitening broth,
> That the metal pure and choice
> May swell the full sonorous voice."

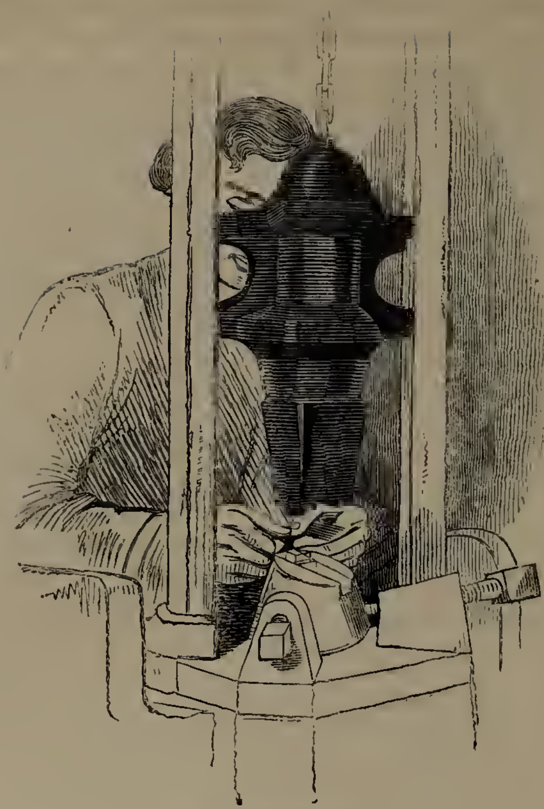
The reader will not have much difficulty in calling to mind numerous allusions to the use of the bell as a symbol of death, of rejoicing, of the passage of time, &c. But leaving these, we find that, let the motives have been what they may, bells have been constructed in some countries of most extraordinary magnitude.

The construction of these monster bells was commenced so early as the sixth century; or, at least, it was about that time that the custom became established of placing in the belfries of churches bells large enough to be heard for a great distance. The monks of Croyland Abbey are said to have had a peal of fine bells in the tenth century; they were five in number, and were designated by the odd names of Pega and Bega, Tatwin and Turketul, Betelem and Bartholomew. Such bells as these were not only rung for the same purposes as in modern days, but for others which no longer accord with the spirit of the age. An old chronicler wrote:—"At Paris, when it begins to thunder and lighten, they do presently ring out the great bell at the Abbey of St. Germain, which they do believe makes it cease. The like was wont to be done heretofore in Wiltshire; when it thundered and lightened, they did ring St. Adelm's bell at Malmesbury Abbey. The curious do say that the ringing of bells exceedingly disturbs spirits."

The possession of a large bell by a town, a college, or a church, is regarded as quite a notable feature; and we can easily obtain records of the most celebrated bells. The "Great Tom of Lincoln," for example, which was constructed in 1610, and remained in constant use for two centuries, weighed nearly 10,000 lbs. It was replaced in 1835 by the new "Great Tom," which was 2000 lbs. heavier. The great bell of St. Paul's weighs between 11,000 and 12,000 lbs., and measures nine feet in diameter. The "Great Tom of Oxford" is larger than any of these three; it is upwards of seven feet in diameter at the rim, has a height of five feet nine inches, is six inches thick at the striking part, and weighs 17,000 lbs. During the present year (1845) a bell has been cast for York Minster, which greatly exceeds them all; it weighs more than 27,000 lbs., is seven feet seven inches in height, eight feet four inches in diameter, and cost about 2000*l.*

Yet vast as these bells seem to be, they are insignificant compared with some in foreign countries. In Fig. 1078 is a comparative view of five bells, in which the relative sizes are correctly preserved. It will here be seen that the "Great Tom at Oxford" is really a very little Tom when compared with others. At Erfurt is a bell more than ten feet high; at Rouen is one yet higher; while at Pekin in China there is a curiously shaped bell more than fourteen feet high by thirteen wide. But Russia is the great country for bells. The "Tsar-Kolokol" and the "Bolshoi" are the largest bells in the world. It is said that the "Tsar-Kolokol," or king of bells, contains metal enough to make thirty-six bells as large as the great bell of St. Paul's; the weight being 400,000 lbs. The bell has long been lying in a cavity beneath the tower of the cathedral at Moscow. It was made from an old bell which was destroyed about the beginning of the last century; aided by contributions of metal from royal and noble personages. Nay, it is said that persons in Russia had such a superstitious veneration for this bell, that they brought metal from every part of the empire to add to the store; and nobles vied with each other in casting gold, silver, and trinkets among the melting ingredients. The bell was suspended in the year 1737, from immense oaken beams, but the woodwork having on one occasion caught fire, the bell fell down, and a piece was broken out large enough to admit two men abreast into the interior. Dr. Clarke says that "peasants visit the bell as they would resort to a church, considering it an act of devotion, and crossing themselves as they ascend and descend the steps. The bottom of the pit is covered with water and large pieces of timber; these, added to the darkness, render it

1068.—Straightening Needles.

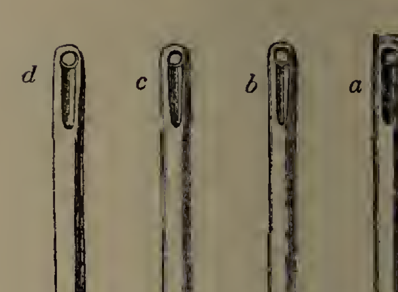


1069.—Stamping Needles.

1072.—Rubbing Needles.

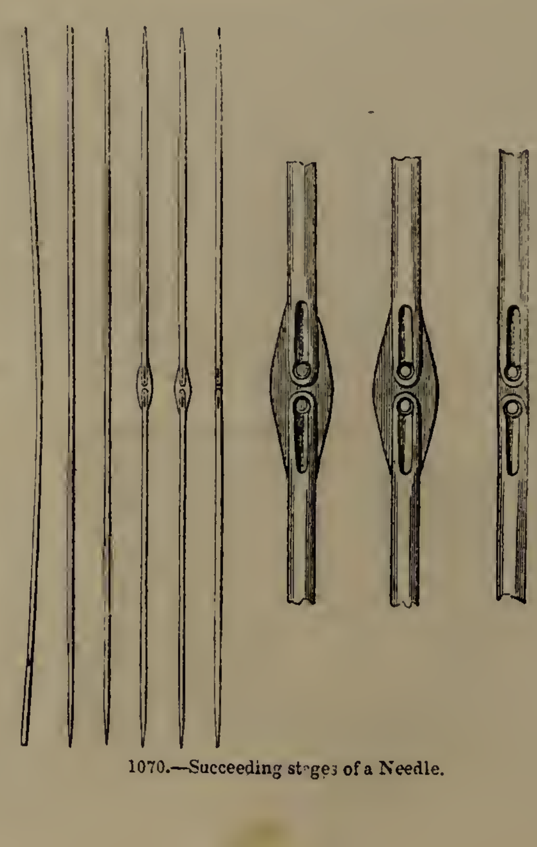
1071.—Needle-grinding or pointing.

1073.—A row of double Needle-wires.

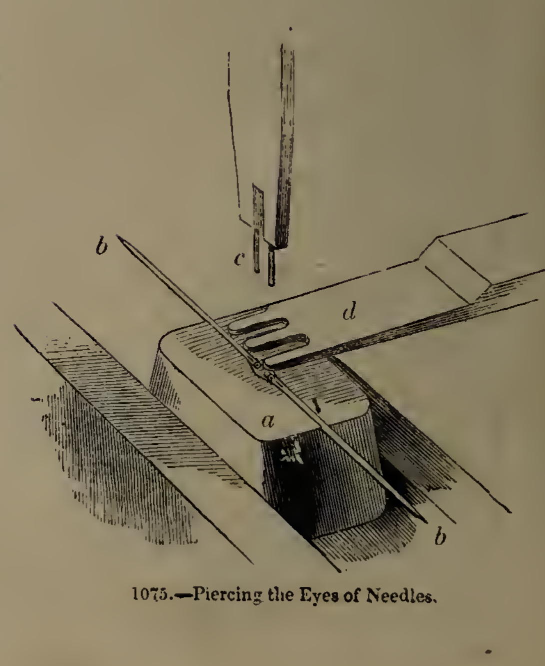


1074.—Needle-eyes, in different stages.

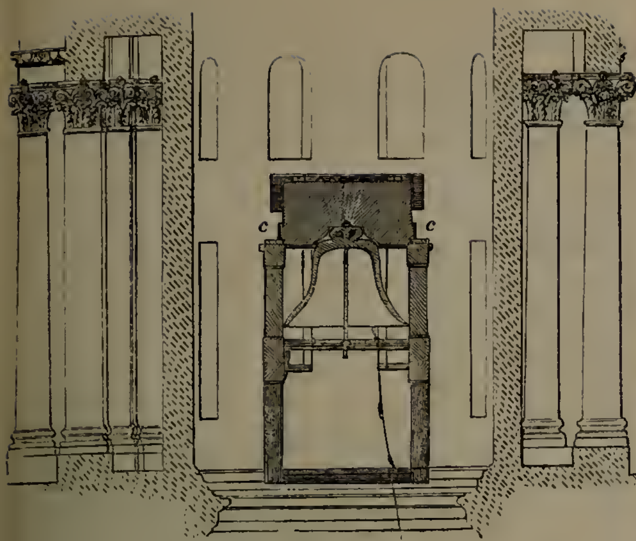
1076.—Egyptian Cutlery-grinder.



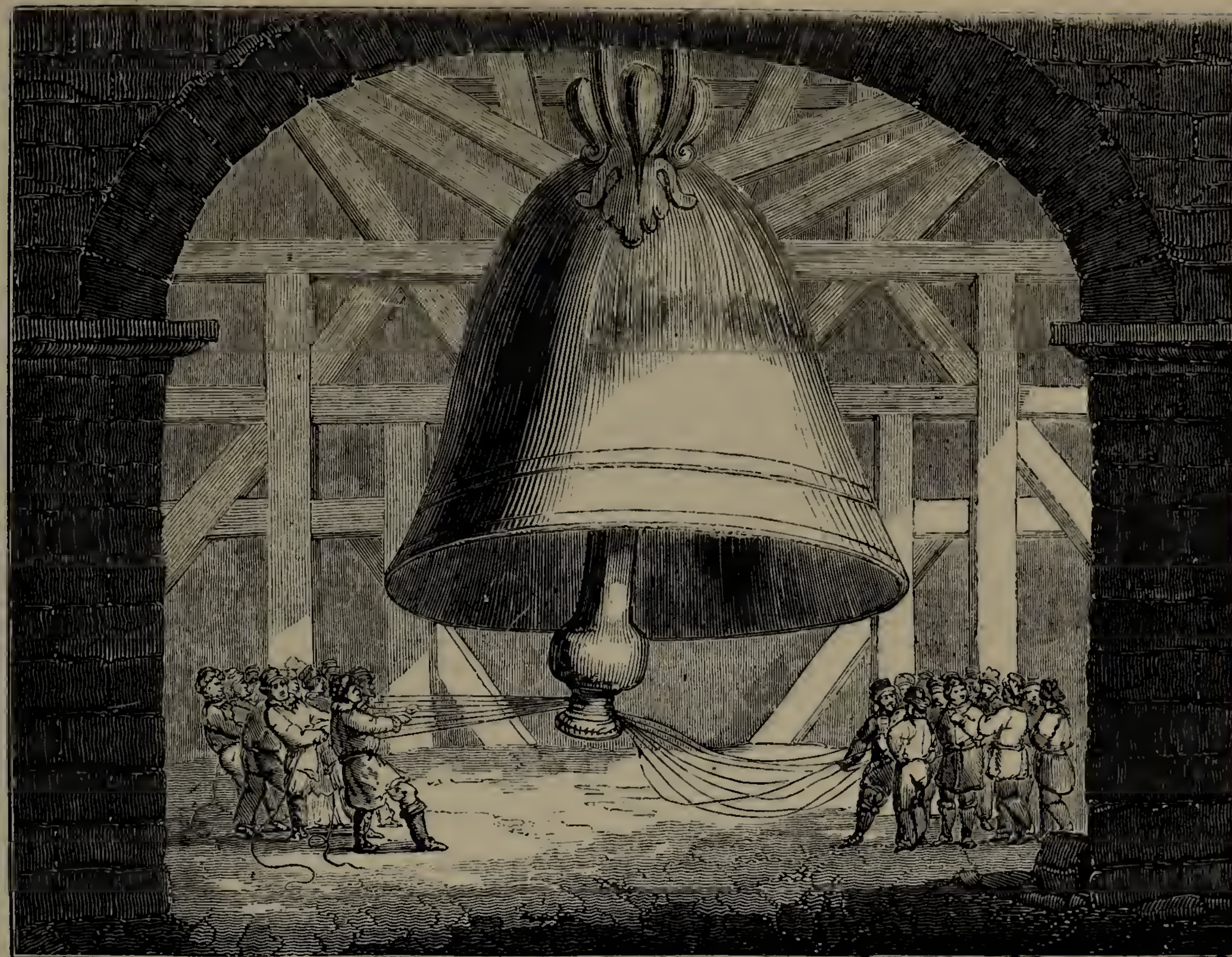
1070.—Succeeding stages of a Needle.



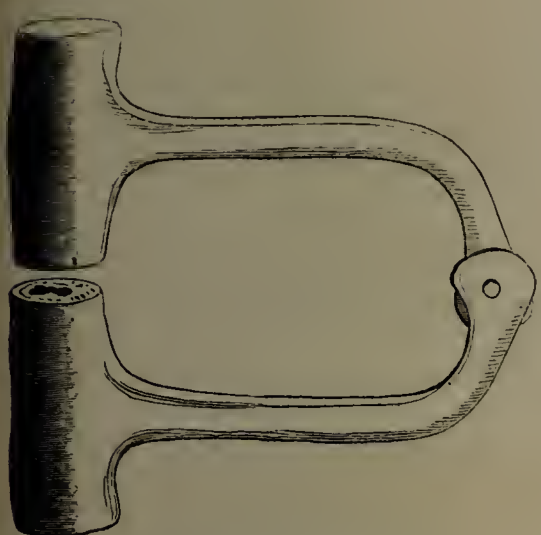
1075.—Piercing the Eyes of Needles.



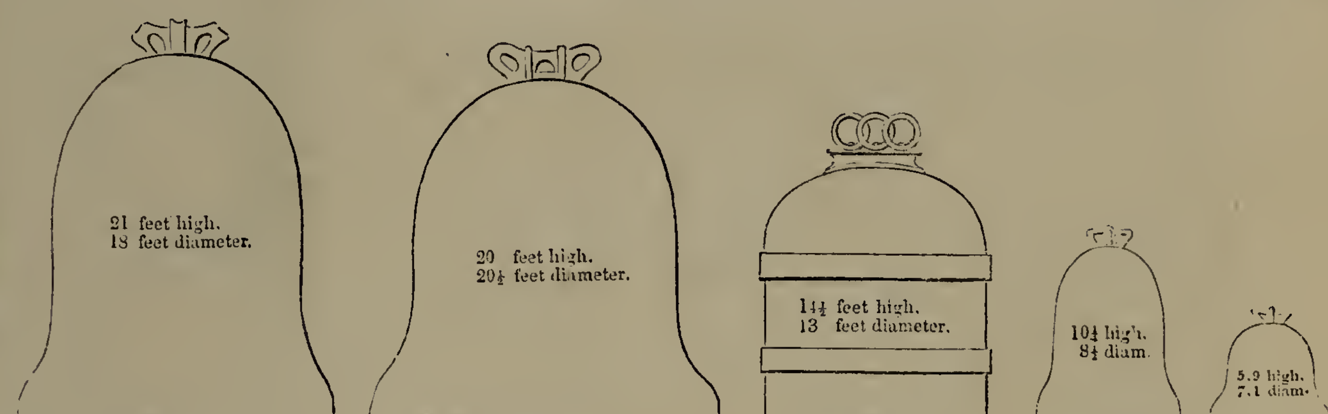
1081.—Belfry at St. Paul's.



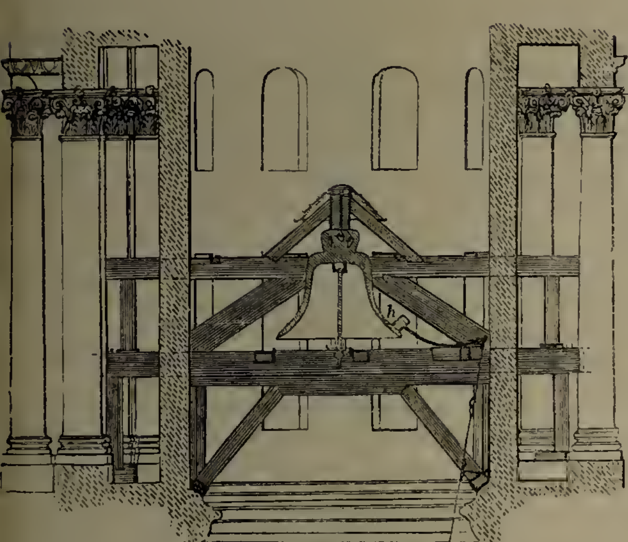
1079.—" Tsar Kolokol," or King of Bells, at Moscow.



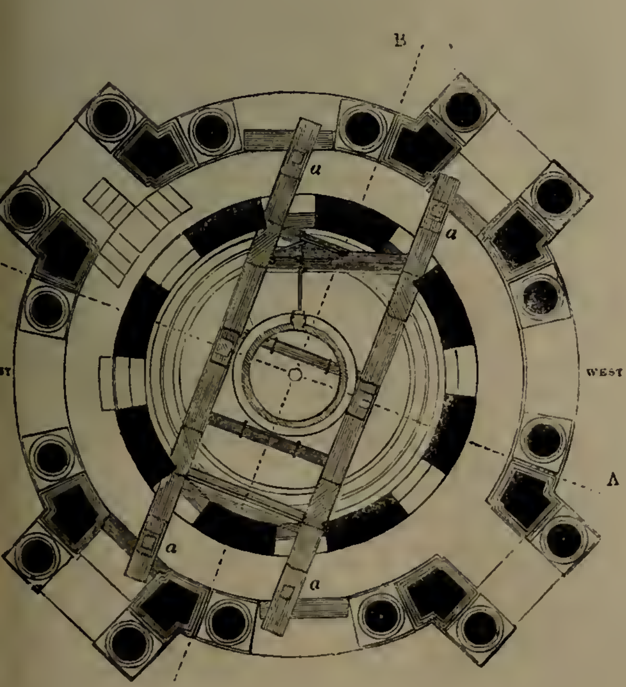
1083.—Roman Coin Mould or Die.



1078.—Comparative dimensions of celebrated Bells.



1082.—Belfry at St. Paul's.



1080.—Plan of the Belfry of St. Paul's

1077.—Manufacturing Copper Vessels.

always an unpleasant and unwholesome place, in addition to the danger arising from the ladders leading to the bottom."

Since Dr. Clarke wrote, however, a remarkable enterprise has been conducted, viz., the suspension of this ponderous mass from beams above. Although no distinct evidence of the fact has been preserved, yet it is believed that the "Tsar-Kolokol" was originally suspended, and that the clapper was worked by a number of men by means of ropes, as represented in Fig. 1079; and to restore it to a similar position was the object of an ingenious operation conducted in the year 1836. The matter was thus spoken in the scientific journals at the time:—"M. Montferrand, a gentleman greatly distinguished in Petersburg by the numerous works he has executed, was intrusted with the direction of the operations. As the bell was lying in a cavity in the ground, and more than thirty feet below the surface, a large excavation was made to clear it. Over this was constructed a strong and lofty scaffold for the attachment of the blocks and for the temporary suspension of the bell at the proper height. At half-past five in the morning, the authorities of Moscow and a large number of spectators being assembled on the spot, prayers were offered up for the success of the attempt, and the operations commenced on a signal given by M. Montferrand. Six hundred soldiers simultaneously set to at a large number of capstans. The enormous weight was mastered, and the bell was soon seen to rise slowly in the pit. Forty-two minutes elapsed during its elevation to the necessary height. No accident occurred. The first operation being finished, the next was to build a platform beneath the suspended bell. This was completed in eight hours, and the bell lowered upon it. On the following day it was placed on a sledge and drawn, by means of an inclined plane, up to the pedestal intended to support it, and there finally left." It is more as a curiosity than anything else that the bell has been thus raised; for the large hole in it has effectually ruined its resonant quality.

The other Russian bell sketched in Fig. 1078, named the "Bolshoi," or large bell, was cast to replace one destroyed by the French during their brief residence in Moscow in 1812. The materials of the old bell, other metal given by the Emperor, and precious metal given by the nobles, were thrown into the casting furnace, and the new Bolshoi made therefrom. It is about twenty-one feet high by eighteen in diameter, and weighs 144,000 lbs.—an enormous weight certainly; but still far below that of the "Tsar-kolokol." The tongue or clapper alone weighs more than 4000 lbs. This bell is regularly suspended fit for use; and its suspension was attended with some such a ceremony as in the case of its monster companion:—"On the 3rd of February, 1817, the New Bell was moved with great ceremony on a large wooden sledge from the foundry to the Cathedral; a Te Deum was celebrated, and the labour of dragging the sledge committed to the multitude, who disputed the honour of touching a rope. The movements were regulated by little bells, managed by M. Bogdanof, who stood on a platform attached to the bell. Part of the wall was taken down to admit its passage; and, as soon as it reached its destination, the people leaped upon M. Bogdanof, kissing his hands, cheeks, and clothes, and showing, by every means in their power, the gratitude they felt at the restoration of their old favourite. Some days after this the New Bell was slowly raised to the place of its predecessor, and properly suspended. This bell is said to produce a sound which vibrates all over Moscow like the fullest and lowest tones of a vast organ, or the rolling of distant thunder."

In the manufacture of large bells, a process of casting or founding is adopted, very similar to that followed in other branches of metallurgy. There is first built up a mass of brickwork to form the core or mould, shaped like the bell, but rather smaller than its internal diameter. This is coated externally with a composition of clay or earth; and the damp surface is worked to a true contour and smooth surface by means of gauges or modelling tools, so as to present—both as to size and to device or surface—an exact reverse of the intended interior of the bell. This coating is thoroughly dried in a kiln; and when dry a little tan-dust is sprinkled on it, to prepare it for the reception of a second layer. This outer layer is brought to a surface exactly resembling the exterior of the intended bell. This in its turn being dried, a sprinkling of tan-dust is applied, and a third layer of clay put on, much thicker than both of the others. This is dried, and when dry it is lifted off the previous coatings as a separate cap or cover, which is enabled to be done because the tan-dust prevents the adhesion of the different layers. The second or middle layer is then picked away piece-meal; and the outer case being put on again, there is space existing throughout the whole mould equal to the thickness of the intended bell. It will be easy to see that the object of the three layers of clay is as follows:—the inner one gives the inner contour to the bell; the outer one gives to it the external contour; and the middle one determines the thickness of the metal.

This mould of brickwork is built up in a pit so as to be entirely below the level of the ground in the casting-house. Near the pit is a furnace, with an opening at the top where the metal is thrown in, and a small orifice at the bottom whence the melted metal flows out when the mould is prepared to receive it. The materials of bell-metal are, as was before observed, copper and tin, in the proportion of about four of the former to one of the latter. Old copper ship-sheathing is very often employed for this purpose. The heat is obtained from dry billet-wood, which is found to injure the metal less than any bituminous fuel. When thoroughly melted the metal presents the appearance of liquid fire; and, on the opening of a small hole at the lower part of the furnace, it gushes out, and flows along a channel to the casting-pit (which has been previously filled up with loam to the level of this channel). The metal finds an entrance into certain openings left in the loam, and gradually fills the bell-mould beneath. When the metal has solidified, the mould is pulled to pieces, and the bell finished up by hand. Sometimes many bells are cast together in one pit (as in Fig. 1084); there being openings left in the loam above each mould.

It may be a matter of wonder to many persons to conceive how such ponderous masses of metal as the various "Great Toms" can be suspended in safety. This may be in part illustrated by the arrangements shown in Figs. 1080, 1081, 1082, relating to the belfry of St. Paul's. In Fig. 1080, for instance, we have a plan of the belfry, the eye being supposed to be at the top, looking downwards. The two massive beams, *a a*, are those which mainly support the bell. There are two dotted lines drawn across the plan, A A and B B: these represent the directions in which the two vertical sections are taken; the section shown in Fig. 1081 corresponding with the line A A, and that shown in Fig. 1082 with B B. In these sections the general mode of support is exhibited, *h* being the hammer.

Brass and Bronze.

So much similarity is observable in the modes of working in the different combinations of copper with other metals, that the same description will apply pretty accurately to all of them. In brass founding and working, for instance, the making of the moulds, the melting of the metal in furnaces, the casting and subsequent trimming and finishing, the rolling into sheets, the drawing into wire—all are conducted pretty nearly in the same way as for other metals. The making of the brass itself is, however, rather a delicate operation. This metal consists of about two parts of copper to one of zinc; the proportion not being exactly equal in all specimens. In the first place the copper is melted, and poured into cold water, by which it is made to separate into small pieces varying from the size of a small shot to that of a bean, and known as "shot-copper." The zinc is produced from a carbonate of the metal, called "calamine;" this is broken into small pieces, heated to redness in a furnace, reduced to a fine powder, and washed. Any quantity of the powdered calamine is then mixed with three-fourths of its weight of "shot-copper," and an amount of charcoal equal in bulk to both. The mixture is exposed to a strong heat in earthen crucibles for several hours; at the end of which time the two kinds of metal have combined together in a liquid state, and the charcoal has disappeared. The brass, formed by the union of the two metals, is poured either into large flat granite moulds, or into smaller moulds of cast-iron, according as it is to be afterwards rolled into sheets or cast into small articles. Sometimes brass is made by the direct union of zinc and copper; but this is a more difficult process than when calamine is employed instead of metallic zinc.

Bronze, like bell-metal, is a mixture of copper and tin, but the proportions depend partly on the purposes to which it is to be applied, and partly on the opinions of the maker or artist. Bronze is a term frequently applied to the metal used for cannon, as well as for statues; and under this designation the French founders are said to employ, for cannon, a ratio of 100 copper to 11 tin. Cymbals contain 78 copper to 22 tin; medals, 100 copper to about 10 tin; statues (on Mr. Westmacott's plan), gun-metal, with 30 per cent. of pure copper added to it.

The mode of proceeding in casting a bronze statue is much the same in principle as that of casting large bells, but with greater precautions in every part of the operation. The making of the original model belongs to the highest department of art; for it is here that the sculptor shows his consummate skill, by imparting to the lifeless clay almost a living expression: all beyond this, although requiring a very high degree of care, is still mechanical, and governed by mechanical rules. One of the most graphic accounts ever given of the casting of a statue, with the uncertainties and difficulties attending it, is that which is contained in Benvenuto Cellini's Autobiography. "This eminent man," says a writer in the 'Penny Cyclopædia,' "had been engaged on his fine group of Perseus and Medusa, during which, by the jealousy of rivals and the ill-conduct of his workmen, he had been subjected to every kind of annoyance and disappointment. At length his labours seemed to be nearly at an end; his mould was lowered into the pit, the furnace heated, and the metal thrown in. At this time, while a violent storm raged without, the roof of his study, as if to increase the confusion, caught fire; but, though ill and harassed, he still directed the works and encouraged his assistants, till overcome by anxiety and fatigue he retired in a raging fever to lie down, leaving instructions respecting the opening of the mouth of the furnace and the running of the bronze. He had not, he says, been reposing very long before one came running to him to announce evil tidings: the metal was melted, but would not run. He jumped from his bed, rushed to his studio like a madman, and threatened the lives of his assistants, who, being frightened, got out of his way, till one of them, to appease him, desired him to give his orders, and they would obey him at all risks. He commanded fresh fuel to be thrown into the furnace; and presently, to his satisfaction, the metal began to boil. Again, however, it appeared thick and sluggish, and refused to run. He then ordered all the plates, dishes, and other articles of domestic use in his house to be brought to him, which he threw pell-mell on the metal; when it immediately became fluid, and the mould was soon filled. He adds that he fell down on his knees, and poured forth a fervent thanksgiving to Almighty God for the success that had crowned his exertions."

Coining.

The process of *coining* may, in some respects, be ranked among those here treated; for copper is the metal most largely used for this purpose, though its intrinsic value is much less than that of the silver and gold employed. The metal for such purposes is in the first instance rolled out to the state of sheets; these sheets are cut up into blanks, and the blanks are stamped on both sides at once, by means of hard steel dies, one to give each side of the impress. A curious record of past times has been dug up among the Roman remains in Britain, viz., a sort of coin-mould or coin-die (Fig. 1083). This seems to consist of two dies, one to give each side of the impress to a coin; the two are so hinged together as enable the one to be brought down on the face of the other. Supposing a blank piece of metal to be placed between them, a smart blow from a hammer would give the double impress of a coin to it; but if metal in a semi-solid state (such as a soft kind of metal occasionally employed to produce "cliché" medallions) were used, a slight pressure would suffice to give the impress. In another cut (Fig. 1089), copied from an old German print, a curious representation is given of a party of men busily engaged in coining, as it was conducted in the rude style of former days. There is a furnace, containing the crucibles in which the metal is being melted; a man is hammering the cast metal into sheets; another cutting the metal with a pair of shears; another stamping by means of the die, aided by a boy; while the master-coiner, giving instructions to an assistant, seems to be keeping an account of the whole arrangements.

The process of coining in the Mint of London is very different indeed from the above, and is considered to be unequalled in any other country. The metal is first brought to the state of oblong bars, and the processes which then follow are thus given in 'London,' No. 53:—"The bars, in a heated state, are first passed through the breaking-down rollers, which by their tremendous crushing power reduce them to only one-third their former thickness, and increase them proportionably in their length. They are now passed through the cold rollers, which bring them nearly to the thickness of the coin required, when the last operation of this nature is performed by the draw-bench—a machine peculiar to our Mint, and which secures an extraordinary degree of accuracy and uniformity in the surface of the metal, and leaves it of the exact thickness desired. The cutting-out machines now begin their work. There are twelve of these engines in the elegant room set apart for them, all mounted on the same basement, and forming a circular range. Here the bars or strips are cut into pieces of the proper shape and weight for the coining-press, and then taken to the sizing-room to be separately weighed, as well as sounded on a circular piece of iron, to detect any flaws. The protecting rim is next raised in the marking-room, and the pieces after blanching and annealing are ready for stamping. The coining-room is a magnificent looking place, with its columns and its great iron beams, and the presses ranging along the solid stone basement. There are eight presses, each of them making, when required, sixty or seventy (or even more) strokes a minute; and at each stroke a blank is made a perfect coin—that is to say, stamped on both sides, and milled at the edge—each press will coin between four and five thousand pieces in the hour, or the whole eight between thirty and forty thousand. And to accomplish these mighty results the attention of one little boy alone is required, who stands in a small place before the press, supplying it with blanks." These details relate chiefly to the coining of silver and gold; but they are also applicable in their main features to the coining of copper.

All the usual mechanical operations can be effected on copper, brass, and their alloys, as on other metals. Wire-drawing, for instance, is similarly conducted; so is the rolling into thin sheets. A "draw-bench," too (Fig. 1086) is often employed to convert thin narrow slips of this metal into beading or mouldings, by drawing them forcibly through a small hole presenting the section of the moulding, instead of a mere cavity.

Every year adds some to the number of different mixtures or alloys of different metals employed in the arts. This diversity arises from such mixtures often undergoing very notable changes when compared with the component metals separately. If the mechanical or other properties of a mixed metal were always an exact medium between those of the components, then the nature and use of every such alloy could be pretty well predicted. But such is by no means the case. It frequently happens that a mixed metal is harder than either of the two from which it was formed; sometimes it is softer, sometimes its bulk is smaller than that of the other two united, thus showing that a condensation has taken place; on other occasions the alloy will melt at a much lower temperature than either of the single metals; and in others, it is whiter than them. As the state of knowledge on these subjects is not such as to give the power of predicting these qualities or changes of qualities until tried, there is a constant incentive to experimental research, as a means of discovering some new mixture of metals which will be of value in any particular department of the arts. Thus, a new white and hard metal for the basis of silver-plate; a white and soft metal, under the name of "Britannia" metal, for small culinary vessels; a very fusible metal for some sorts of casting; a fusible but yet hard metal for types; an exceedingly hard metal for the nibs of gold pens; a metal of brilliant whiteness for the specula or reflectors of large telescopes—all of these are obtained by mixing together two or more metals, none of which exhibit the requisite qualities when single.

Before speaking of *Tin*, a metal which is largely employed in many of these alloys, it may be well to notice a branch of manufacture which occupies a curious link between many of the others; viz.,

Button-making.

There is scarcely one among the commonly known metals that is not, in some way or other, employed in making buttons; gold, silver, mercury, copper, tin, brass, lead, steel, iron—all come into requisition for these small but curious and important appendages to the toilet. The manufacture is much more important than we should at first thought be apt to suppose; and any material change of fashion in this respect is a matter of serious moment at Birmingham, where the trade is chiefly carried on. The materials of which buttons have at different times been made comprise gold, silver, plated copper, white metal, pinchbeck, steel, iron, japanned tin, glass, foil-stones, mother-of-pearl, ivory, bone, horn, tortoise-shell, jet, cannel-coal, papier-maché; besides moulds of horn or bone, covered with cloth, mohair, silk, velvet, and other textile material. Whenever a change has taken place in the kind of button recognised as "fashionable," some or other of the dealers in the above materials suffered by it; and workmen who were accustomed to apply their ingenuity to one kind of button only, became threatened at such a time with loss of employment. During a considerable part of the last century, buttons were worn in which there was a central mould of bone or wood, covered externally with thread made of gold, of silver, of silk, or of some commoner material. This thread was wound on the button-mould by females, who were employed in considerable numbers at this business; since each button was wrought singly, in rather a slow manner. When changing fashions led to the plan of covering buttons with the same kind of material as that employed for the garment, these workers felt the effect of the change; and a petition was presented to Parliament, in which the grievance was set forth in the following way:—"It appears by long experience that needle-wrought buttons have been a manufacture of considerable importance to the welfare of this kingdom; inasmuch, that whenever such buttons have been disused, the wisdom of the nation hath always interposed, as may be seen by the several Acts passed in the reigns of King William, Queen Anne, and of his Majesty in this present Parliament. Yet, notwithstanding the said Acts, the tailors continue to make buttons and button-holes of the same material the clothes are made of; and the said Acts cannot be put in execution, because of the great difficulties that attend the detection and prosecution of the offenders."—As may be supposed, the prayer of the petitioners was almost as fruitless as are all attempts to legislate concerning the kind of clothes which a man may wear.

A gilt coat-button, such as were largely worn a few years ago, though now superseded to a considerable extent by those of silk, will exhibit the chief features of the manufacture, so far as metal buttons are concerned.

In the first place, the "blank," a circular piece, is cut out of sheet copper, or of copper alloy. Females, seated in front of a long bench, have small stamping-presses before them, with which they stamp out the blanks very rapidly, each blank being a slight degree larger than the button which it is to form. If for a plain gilt coat-button, as we have supposed, this stamping or cutting out is the simplest of the whole; but if for convex or concave or brace buttons, the blanks are stamped in a die, after being cut out, in order to give them the required curvature of surface. So extremely quick are the movements of the persons thus employed, that thirty blanks will sometimes be stamped in a minute. If there is a device on the surface, such as is generally presented by livery-buttons, the sheet from which the blank was cut is rather thicker than in other cases; and the stamping requires the aid of a powerful press, in which the upper die is let fall on the blank by a powerful hammer, suspended from a string governed by the foot of the workman (Fig. 1091).

When the blank for a plain button has been cut out, it is fixed in a lathe, and turned, to remove all rawness or irregularity of the edge. If there are holes in the button, as in a common brace-button, these holes are made by using a drilling-machine with four little drills or piercers, all of which are revolving so as to pierce the holes readily when the blank is applied to them. But for those buttons which have "shanks," or small loops of wire for attaching them to the garment, the shanks are first made in a beautiful machine, where a piece of brass wire is drawn out, straightened, cut off to the proper length, bent to the proper curvature, and levelled at the joint. These shanks are placed in the hands of a female (Fig. 1092), who solders them to the blanks with remarkable rapidity. She lays down each blank separately on a flat table, takes up a shank and places it in the right position on the blank, clasps a little spring or piece of bent iron over the two to keep them together, touches them at the joint with a little solder, and places it on an iron plate. She treats them one after another in the same way, until the iron plate is filled; and it is then placed in a kiln or oven heated to a sufficient degree to melt the solder and make the shank unite firmly with the blank.

The gilding of such buttons as these is a curious operation. Some are gilt all over, and are then technically termed "all-overs;" while others are gilt only on the outer surface, and these are called "tops." The two kinds are gilt in a different manner. The best kind, which are gilt all over, are first cleaned well in an acid, and put into a vessel containing a solution of gold with some liquid nitrate of mercury. The whole are worked up in the vessel together, and a chemical action takes place, by which the nitric acid aids the mercury to combine with the copper, and the mercury aids the gold in doing the same thing; so that, although the object in view is really that of applying gold to the surface of copper, two intermediate agents are required. When the buttons are to be coated only on the external surface, they are laid out flat by placing their shanks in a row of little holes, and are then brushed over the exposed surface, first with nitrate of mercury, and then with an amalgam of mercury and gold.

When supplied with their quota of gold-amalgam (which is a sort of paste), the buttons, whether they are to be gilt all over or only on the tops, are put into a wire-gauge cylinder, which is placed in a cylindrical oven only a little larger than itself. There is a long handle projecting in front; and a female, by keeping this handle always rotating (Fig. 1096), causes the buttons to roll and mix among each other, by which each one becomes equally exposed to the heat. The warmth of the oven drives off the mercury of the amalgam in the state of vapour, which escapes from a pipe at the back of the oven; and the gold is left adhering to the copper surface of the button. This is a process which, as formerly conducted, was one of the most unwholesome in the whole circle of the mechanical arts; since the mercurial vapour used to be inhaled by the workmen, to the ruin of their health.

A very curious process is adopted of silvering some of the smaller kinds of buttons, as well as livery-buttons. They are put into an earthen pan, together with a mixture of silver, common salt, cream of tartar, and one or two other ingredients. They are all stirred round together in the pan with a brush; and in a very few seconds the buttons are found to be coated equally and uniformly with silver; for the alkaline agents tend to make the silver unite quickly with the metal of the buttons.

The gilt-buttons, as they come out of the gilding-cage, have a brownish appearance, and present very little of the beauty which belongs to a finished button: they require "burnishing;" preparatory to which several minor processes are conducted, having for their object to cleanse the surface of the gold, to heighten its colour, and to prepare it for the action of the burnisher. This burnisher consists of a piece of very hard and smooth stone, fixed at the end of a wooden handle. The workman who undertakes this part of the operations has before him a small lathe, to which he attaches the buttons one by one; each button is made to revolve rapidly, and the burnisher, dipped into water to keep it cool, is applied to the surface (Fig. 1100); by which, in the course of a very few seconds, the golden surface is brought to a very great degree of brilliancy.

The manufacture of other kinds of buttons depends principally on the kind of materials from which they are made. Thus, horn-buttons are often made by pressure in a die or mould; the horn, when softened by heat, is easily impressed with a device, and when cold it assumes all its former hardness. "Florentine," or silk buttons, are curiously made by the combination of a number of little circular pieces of iron, paper, canvas, and silk, pressed together with admirable neatness and precision.

Metallic Reflecting Mirrors.

Whoever might walk through the various rooms of the British Museum, would find curious examples of the use of different metals in ancient times, including all those which have already engaged our attention, such as iron, steel, brass, bronze, copper, &c.; as also alloys of other metals yet to be noticed. Idols, lamps, grotesque figures, busts, rings, coins, vases, urns, salvers, shields, warlike instruments—all are to be there met with, manufactured from various metals, and brought from various countries. Sometimes, in the excavation of an Egyptian tomb, articles of this kind have been met with; at others, in digging up the ground where a building, or a town, or a burial-place had formerly been, urns or coins or other specimens have come to light. Many such have been represented in a former page of this chapter.

That the various nations of early times and of eastern countries in the present day, were in the habit of forming vessels and other articles of metal, we have proof enough, not only in collections of antiquities and curiosities, but in the volumes which have been published relating to Pompeii, Herculaneum, Thebes, &c. A few specimens are sketched in Figs. 1085, 1087, 1088, 1090, 1094, 1095, 1097, 1098, 1099. Two of these represent metal *mirrors*, a sort of luxury to which the "looking-glasses" of modern days have furnished a substitute. There is a passage in the 20th chapter of Exodus, which, as Beckman observes, shows that mirrors made of polished brass were in use in those days. Moses ordered certain brass mirrors, which were brought to him, to be made into washing-basins or lavers. Some writers think that the mirrors, instead of being transformed into lavers, were merely hung round them by way of ornament.

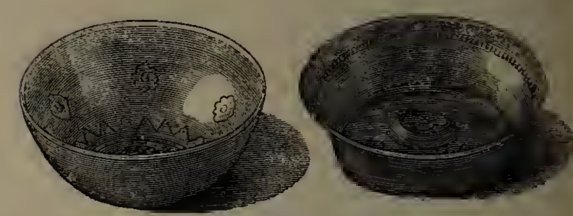
Some of the ancients were accustomed, in fashioning a metal cup or drinking vessel, to cut the inside so as to present a number of flat surfaces; which, being polished, afforded multiplied reflections of the face of the drinker. Praxiteles, in the time of Pompey, is said to have made the first mirror of polished silver; and after his time there was such a demand for these luxuries as to lead to the establishment of a distinct branch of manufacture for them at Rome. There was a mirror found during the last century among some ruins at Brundusium, which, on analysis, was found to consist of an alloy of copper and tin. Another showed indications of copper, lead, and antimony.

While upon this subject, we may fittingly offer a few remarks on the *specula* or polished metallic surfaces of reflecting telescopes. These admirable instruments, telescopes, are divided into two great classes—not in relation to their power and efficiency—but to the mode in which the rays of light are brought to the eye of the observer. In the "refracting telescope" there is a convex lens at the outer or wide end, by which the rays of light are refracted or brought to a focus within the tube; and by other arrangements of lenses near the other end, the rays are bent into a proper direction to enter the eye. In the "reflecting telescope" the outer end is open, unoccupied by a lens, and free for the entry of rays of light into the tube; near the lower or inner end of the tube is a concave "speculum" or reflecting mirror, whose surface is so highly polished as to reflect the rays of light back again towards the outer end of the tube; in their regression, however, they encounter another reflector, smaller than the former, by which they are again reflected, and finally allowed to pass to the eye of the observer at the smaller end of the tube.

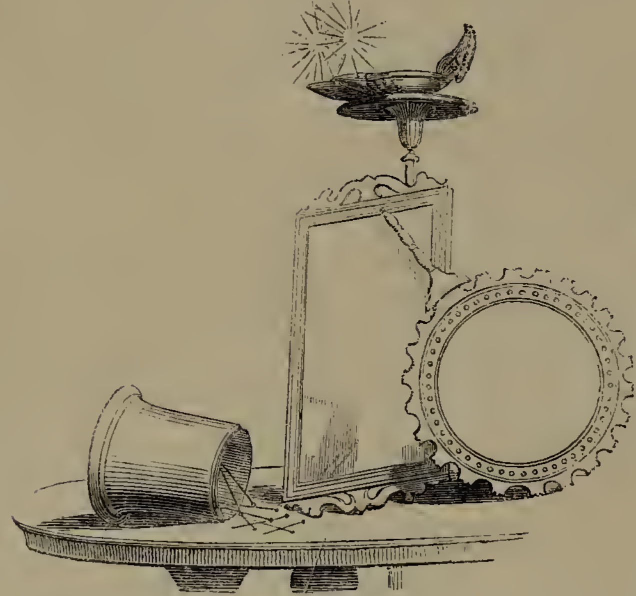
The manufacture of the reflectors or specula here alluded to is a most delicate and difficult operation. The curvature of surface requires to be most minutely attended to, in order that the convergence of the rays may be brought about to the right degree and at the right spot. The composition of the speculum, and the polishing of its surface, are other points of great importance. It may appear remarkable that the whitest and most brilliant metal known for this purpose is a mixture of several metals which are not at all fitted for the object in their simple or separate state. Copper and tin—the two components which supply so many different alloys for bronze, bells, guns, and other articles—are also the two which are most valuable for reflectors. Towards the latter end of the last century, the Rev. Mr. Edwards, a practical astronomer of much ingenuity, made an extensive series of experiments, with a view of determining what combination of metals would produce the best alloy for specula. He employed copper, tin, silver, platina, iron, bismuth, brass,

1085.—Ancient Metal Mirrors.

1086.—Drawing bench for making Metal Beading.



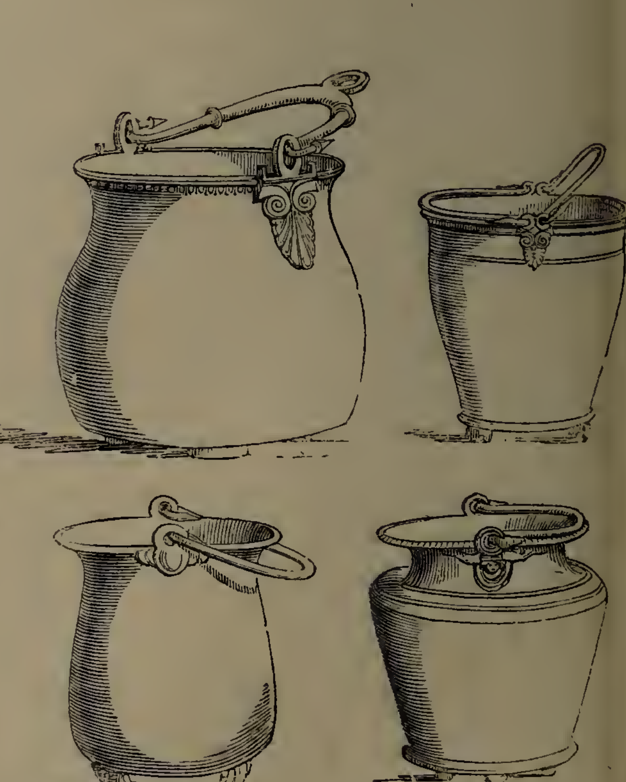
1087.—Egyptian Brass Vessels.



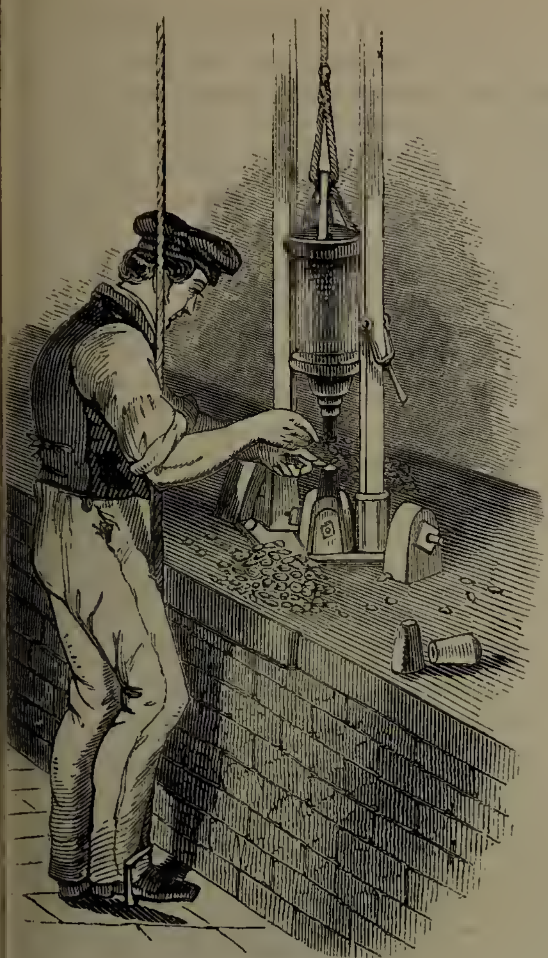
1088.—Ancient Metal Mirrors.

1089.—Coining: as sketched in an old German Print.

1084.—Casting-pit of a Bell-Foundry.

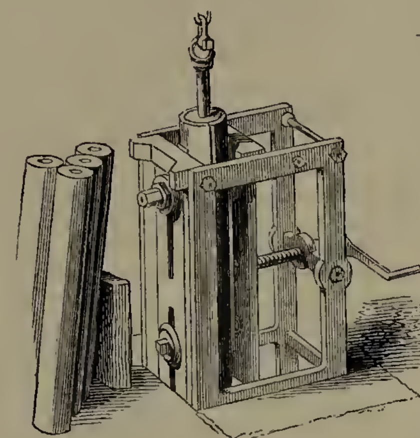


109 .—Bronze Vessels, from Pompeii.



1091.—Stamping Buttons.

1094.—Bronze Strainer, from Pompeii.

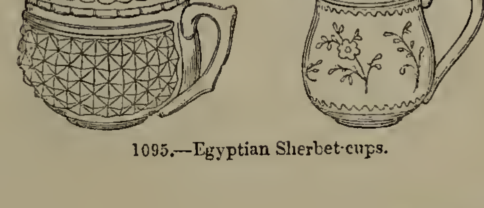


1101.—Mould for casting Lead-pipe.

1096.—Cage and Oven, for Button-gilding.

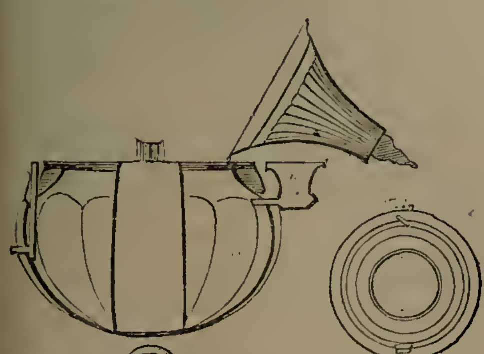
1092.—Button-making.

1093.—Soldering Button-shanks.

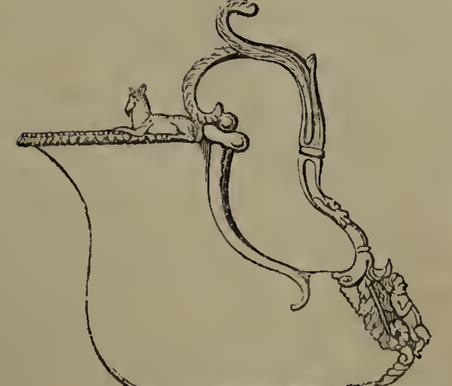


1095.—Egyptian Sherbet-cups.

1100.—Burnishing Buttons.



1097.—Metal Urn, from Pompeii.



1098.—Bronze Vessel, from Pompeii.

1099.—Bronze Vase, from Pompeii.

lead, antimony, arsenic, and zinc; he combined these, two or more together, and in various proportions; and he published, in the 'Nautical Almanac' of that day, a long list of the results which he had obtained. Some of his alloys were too soft; some too hard; some deficient in whiteness; some defective in the power of receiving a high polish; and some wanting in one or other of the requisite qualities. The alloy which he preferred to all others was a mixture of thirty-two parts copper, fifteen tin, one brass, one silver, one arsenic. It is singular that this composition agreed very nearly indeed with that which Sir Isaac Newton had adopted in the previous century; and ever since then the ratio adopted has been about two of copper to one of tin, the other ingredients (if any) being extremely small in quantity.

Most readers are aware that the late Sir William Herschel was an indefatigable experimenter in relation to all that concerned reflecting telescopes, especially the specula. In an after period of his life, when communicating to the Royal Society an account of his early labours in this department of art, he says:—"When I resided at Bath, I had long been acquainted with the theory of optics and mechanics, and wanted only that experience which is so necessary in the practical part of these sciences. This I acquired by degrees at that place, where, in my leisure hours, by way of amusement, I made for myself several two-feet, five-feet, seven-feet, ten-feet, and twenty-feet Newtonian telescopes; besides others of the Gregorian form, of eight inches, twelve inches, two feet, three feet, five feet, and ten feet focal length. My way of doing these instruments at that time, when the direct method of giving the figure of any of the conic sections to specula was still unknown to me, was to have many mirrors of each sort cast, and to finish them all as well as I could; then to select by trial the best of them, which I preserved; the rest were put by to be re-polished. In this manner I made not less than two hundred seven-feet, a hundred and fifty ten-feet, and about eighty twenty-feet mirrors." This was the sort of enthusiasm, applied to art in aid of science, which was sure in the end to develop something valuable; and the magnificent "great telescope," which has been so many years associated with the name of Herschel, was a worthy climax to such labours. Shortly before making the speculum for his large telescope Sir William endeavoured to make one thirty-six inches in diameter; but the alloy, being too brittle, cracked in cooling. In a second attempt the great weight of metal burst a hole through the furnace in which it was being melted, and rendered the trial abortive. In a third effort, however, he succeeded in producing a speculum which became afterwards the reflector of his great telescope. This speculum was forty-eight inches in diameter, by three inches and a half in thickness in every part, and its weight amounted to about two thousand pounds.

Those who have read the scientific journals during the last year or two must be familiar with the fact, that the Earl of Rosse, an Irish nobleman of great scientific acquirements and liberality, has constructed a reflecting speculum which far exceeds any other yet produced in this or in any other country. All the operations connected with the casting and polishing of the speculum were planned by the Earl himself, and executed under his immediate inspection, in a building erected for the purpose near his residence at Birr Castle in Ireland.

Sir James South, in a communication to the 'Times' newspaper, described very minutely the operations. He gives a picture of the casting-house and its arrangements, by asking the reader to follow him thus:—"Make one extremity of a line $4\frac{3}{4}$ inches long, and bisect a perpendicular to itself of $2\frac{1}{2}$ inches long, and at the other extremity of it bisect another perpendicular to itself of $2\frac{3}{10}$ inches; beyond which perpendicular extend the first-named line $2\frac{1}{2}$ inches. Call the first the *crane* line; the second the *chimney* line; and the third the *mould* line. On the crane-line, at the distances from the chimney-line of $1\frac{2}{10}$, $2\frac{4}{10}$, and $3\frac{6}{10}$ inches, make dots; on the first of these dots place centrically a silver fourpence, on the second, a silver penny; on the third, a sixpence; on the centre of the chimney-line, a shilling; on each of its extreme points, a silver fourpence; on the centre of the mould-line, a crown; on each of its extreme points, a sixpence; and on the uncovered extremity of the crane-line, a card of two inches square, so that its sides shall be either parallel with or perpendicular to the crane-line. Now, supposing these several coins and card to have the same thickness as the silver fourpences, the *tout ensemble* will represent a horizontal section of the foundry; for the three fourpences will represent the crucibles in their furnaces, the shilling the chimney, the penny the crane, the crown the bottom of the mould, the sixpences the iron pouring-baskets, and the card the floor of the annealing-oven."

The apparatus and the mode of proceeding were as follow:—The three furnaces were each about six feet square by eight high, and were built of brick. The crucibles, one to each furnace, were cast-iron vessels, two feet in diameter by thirty inches deep, and weighed half a ton each. The pouring-baskets were of iron, with long handles projecting from one side. The mould was made of iron hoops laid closely one within another, with their edges uppermost; these edges were all turned in a lathe, so as to give a proper concavity to the surface; and on this surface a bed of sand was worked to scrupulous accuracy of form. The speculum was made of about two parts copper to one of tin, without admixture of any other ingredients. The separate metals, fused and broken up, were placed in the crucibles when the latter were highly heated, and there exposed to the fiercest heat of the furnace for nine hours. When ready for use, the crane was employed to draw each crucible out of its furnace, and to deposit it in an iron basket; the three baskets were placed contiguous to the mould; and at a given signal they were all tilted up, and the immense mass of fiery liquid metal poured into the mould. In the space of about twenty minutes the cast had cooled; and being strengthened by an iron hoop adjusted round its edge, it was dragged out of the mould, along a railway, to the annealing-oven, which was at a dull-red heat. Every door and aperture to the oven was closed, and here the speculum remained sixteen weeks, in order that it should cool with the utmost possible slowness and regularity; in short, the fire of the furnace was allowed sixteen weeks to "go out." Unless such a large mass of metal were annealed in this way, it would be too brittle for the services afterwards required of it.

The dimensions and weight of the speculum thus cast were enormous. It was six feet in diameter, five inches thick at the centre by four and a half at the edges, and its weight was more than six thousand pounds.

The polishing of the concave surface of this speculum was the next important stage. The general mode in which this is effected is as follows:—A convex surface of lead and tin is formed; on this is sprinkled fine emery-powder; and the speculum is worked over and over in every direction with this roughened surface. Other tools of brass, and of blue hone, similarly shaped, are also used; and when the concave surface of the speculum has been by this means worked to a true figure, it is polished by means of a convex rubber coated with a layer of black pitch and calcined vitriol. In general, the speculum is worked over the tool; but in the Earl of Rosse's ponderous reflector the grinding and polishing were effected by placing the tool over the speculum, working it by means of a steam-engine, and keeping it at a constant temperature by immersing both the speculum and the rubber in a cistern of running water.

Of this admirable specimen of skill, Sir John Herschel, in his opening address at the Cambridge Meeting of the British Association (1845), said, "The last year must ever be considered an epoch in astronomy, from its having witnessed the successful completion of the Earl of Rosse's six-feet reflector—an achievement of such magnitude, both in itself as a means of discovery, and in respect of the difficulties to be surmounted in its construction (difficulties which perhaps few persons here present are better able from experience to appreciate than myself), that I want words to express my admiration of it. I have not myself been so fortunate as to have witnessed its performance, but from what its noble constructor has himself informed me, of its effects on one particular nebula, with whose appearance in powerful telescopes I am familiar, I am prepared for any statement which may be made of its optical capacity."

Smelting and Working of Tin.

We have had several occasions to allude to the use of tin as a component metal in valuable alloys, but have not yet described the mode of obtaining and working it separately.

Cornwall is the great storehouse for tin, no other part of the world being so abundantly supplied with this valuable material. Tin is never found in the native or metallic state, but occurs as an oxide, which contains about three-fourths of its weight of pure metal. The veins of tin-ore occupy slender fissures in granite and other hard rocks; and the ore also occurs in beds interlying among the strata of slate. Some of the veins "dip" or incline towards the north, while others dip southward; but all have alike a general direction pretty nearly east and west. Some are only a few yards in length, while others have been traced to a distance of two miles; some are only a fraction of an inch in width, while some are several feet.

Sometimes the veins containing the tin follow such a winding course as actually to pass under the bed of the sea, and mining operations have been in many cases carried on beneath the sea. Nay, in one notable instance, an entrance was made to a mine through the sea itself! According to an account given of this singular mine in the 'Cornwall Geological Society's Transactions,' it appears that, about the beginning of the last century, small veins of tin were observed to traverse a rocky shoal which was exposed to view at low water, at the distance of about a hundred and twenty fathoms from the beach. Several modes were suggested of bringing these veins to valuable use; but as the shoal was covered with water ten months in the year, and had nearly twenty feet of water on it at spring-tides, the attempt was abandoned as hopeless. In 1778 a miner named Curtis took up the idea, and set to work in the following manner:—He employed the few short weeks of three summers in making an excavation, while the shoal was dry. A frame of board was then applied to the mouth of the pit, and fastened well to the rock; above this were built up other boards and framing until he had reached a height beyond the access of the tide. He adopted every available plan for securing his scaffolding to the greatest degree; he placed a windlass at the top of the scaffold, and employed four men to work it; and was thus able to continue his excavations beneath the water; but, notwithstanding all his precautions, the water found entrance within his framing, and the work of the miners was precarious and perilous. However, he obtained the aid of some monied men, and year after year he brought his enterprise into a better position. The time that the miners were able to be on the shoal was exceedingly limited, and the difficulties of bringing the produce on shore were considerable; yet the ore, when obtained, was so very rich in tin, as to induce the speculators to continue in spite of all difficulties. After being in operation some years, and yielding tin to the value of about 70,000*l.*, the framework of the mine was one stormy night struck by an American vessel, the mechanism was destroyed, the mine was filled with water, and the enterprise was brought to a precipitate end.

In the general operation of tin-mining, after the ore is brought to the surface it is broken into pieces, which are examined, with a view to the rejection of such as do not appear sufficiently rich in metal to pay for the subsequent operation. When the selection is made, the ore is beaten by the rammers of a stamping-mill; these consist of heavy upright masses of wood, shod with iron at the lower end, and kept in motion by a steam-engine. The ore is beaten first with one rammer, and then in succession with others, and then sifted through several sieves under the surface of water; until at length it is brought to the state of a fine powder. This powder is washed and sifted, over and over again, until it has become by degrees separated from all the earthy impurities, which, being lighter than the tin, allow it to settle at the bottom. This done, another process is necessary for the separation of the pure tin from any other metals which may happen to be combined with it in the ore. This requires the agency of heat. The pounded ore is roasted in furnaces, by which the other metals are gradually driven off. Still the tin is not yet by any means in a pure state; it is even yet an oxide, containing a large amount of oxygen mixed up with the tin. This oxide is sold to the tin-smelters, who mix it with coal and slaked lime, and expose it to the action of heat in a smelting-furnace for seven or eight hours. During this time the lime acts as a flux to facilitate the melting of the ore, and the carbon of the coal absorbs the oxygen of the ore as it is given out. When the separation is thus completely effected, the liquid tin is drawn off into iron vessels, and from thence poured into moulds. Some few impurities still cling to the tin; but these being removed by subsequent processes, the tin is at length poured into granite moulds capable of containing about three hundredweight each. The masses thus obtained are called *blocks*, and the tin prepared in this way (forming the larger portion of that employed in the arts) obtains the designation of *block-tin.*

The finest kind of tin, however, is the produce of "stream-works," as distinguished from "tin-mines," and is known by the name of *grain-tin*. Between and among the hills where the tin-mines are found are valleys filled with large accumulations of gravel, sand, pebbles, and alluvium; among which is a large quantity of very pure tin-ore. It is supposed that these accumulations must have resulted from the disruption of neighbouring veins, but it has not yet been clearly made out how or by what agency the disturbance was effected. One of these accumulations, in the Valley of Pentuan, near St. Austle, gives employment to the stream-works called the "Happy Union." The valley, which is from three to six hundred feet wide, contains an accumulation of gravel, sand, clay, and ore, to the depth of nearly sixty feet. The tin-ore occupies generally the lowest bed of this deposit, and consists of pieces of various sizes up to ten pounds' weight.

The pieces of tin-ore, when gathered and brought to the stream-works, are pounded and washed repeatedly, and taken to a blast-furnace, where, being mixed with wood-charcoal, they are melted by means of a powerful heat. The melted metal flows out into an iron kettle, placed over a gentle fire; it is kept in agitation by flinging pieces of charcoal in it, and working these about by means of an iron rod. The charcoal exerts a clarifying effect on the metal in various ways; and the liquid tin, exceedingly pure and brilliant in colour, is laded out into moulds. When cold, the contents of the moulds obtain the name of "grain-tin," which is of a purer quality than the "block-tin" used for general purposes.

Tin, being a very soft metal, is not used in the arts by itself to so great an extent as when combined in some way or other with other metals. The bright sheets which to many an eye appear like sheets of tin, are in reality sheets of iron coated with a thin film of tin. This is one of the valuable uses of the metal. For all vessels made of iron or copper, and which are liable to be injuriously affected by air, water, acids, &c., a coating of tin is very serviceable. It is applied in the following way:—The sheet-iron coated in this way is of a fine quality, and is brought in the rolling-mill to the required thickness. After being carefully cleansed by immersion in dilute muriatic acid, the sheet of iron is exposed to a strong heat, by which scales of oxide of the metal are made to fall off. It is then, after being passed between rollers, immersed in dilute sulphuric acid, and rubbed with hemp and sand. By these processes the surface of the metal is made very smooth, uniform, and clean, without which condition the tin would not be able to adhere firmly to the iron. An iron vessel is then nearly filled with equal parts of block-tin and grain-tin, and when these are melted a quantity of tallow is added, sufficient to cover the liquid metal to the depth of a few inches—as a means of preventing the oxidation of the surface of the plates. The prepared sheet or plate of iron is dipped into the melted tin, a coating of which firmly adheres to the iron; and the subsequent processes relate chiefly to the fixing of this tin surface so that it shall not be detached from the iron during the application of the latter to useful purposes.

Various small articles of metal are coated on the surface with tin, alike for the production of a white colour and for their preservation; pins and cheap white buttons are among the number. Tin, beaten into thin leaves, called "tin-foil," is used for many purposes, among which is that of a background or support for the mercury used in silvering looking-glasses.

Lead: Smelting and Refining.

Another of the mineral riches with which our country is so happily blessed is *lead*. The parts of England whence it is principally procured are Derbyshire, North Wales, Devonshire, and especially the northern counties of Northumberland, Cumberland, Westmoreland, Durham, and Yorkshire. There is one elevated spot, called Cross Fell, near which all these five counties meet; this is the seat of the lead-mining district, where nearly two hundred mines are or have been worked. Lead is very rarely met with in the pure or metallic state, being obtained from a great variety of ores. The ore from which the largest supply is obtained is *galena*, or sulphuret of lead, containing about seven-eighths of metal. This ore is found in veins, which traverse in various directions the harder kinds of rock, such as slate and limestone; and these veins vary from a few inches to twenty feet in thickness.

When the ore has been dug out from the veins, by the usual process of mining, it is broken into small fragments, and separated by hand from such earthy matters as are easily removed from among it. It is then roasted with coal in a furnace, as a means of getting rid of the sulphur and other volatile ingredients. It is next put into a blast-furnace, called an "ore-hearth," where a powerful heat is employed to bring it to the liquid state; various impurities rise to the surface as a scum or dross, while the liquid metal falls to the bottom, from whence it is allowed to flow out into "pig"-moulds. The slag remaining on the surface still contains sufficient lead to render it worth a further process; it is melted with coke in another furnace, and lead obtained from it. There is even yet a further source from whence the metal is obtained; for, during the several exposures to the action of heat in furnaces, the smoke carries up with it a good deal of volatilized lead, and this, under the name of "smelters' fume," is collected in a separate chamber, and made to give up its lead by a further process.

If the lead thus obtained were pure, it could at once be applied to practical purposes; but it nearly always contains a little silver, and it is often worth while to carry out a wholly distinct train of processes in order to obtain this silver. The ore obtained from the north of England mines yields from two to twenty-four ounces of pure silver to the ton of lead; the average being about ten ounces. Some of the Cornish mines have yielded from sixty to seventy; while one of the Devonshire mines has at some periods been so rich as to yield a hundred and thirty-five ounces of silver to the ton of lead. If the lead is found to yield the ratio of five ounces (much below the general average), it will pay for the expense and trouble of "refining" or extracting the silver; so that we may conclude that nearly all the lead we meet with has been made to give up a little silver which it once contained. One of the great lead-mine proprietors of the north has had a service of plate made from the silver extracted from his own lead.

The refining of lead for the above purpose is a very interesting chemical process. It depends on a difference in the affinity which silver and lead have for the oxygen of the air; the lead combining with the oxygen and forming an oxide, at a temperature which would leave the silver wholly unaffected by the air. The pigs of lead, as brought from the smelting-works, are in the first place put into large cast-iron pots, capable of holding five or six tons each. The lead is melted in these pots by means of fires underneath, and is then kept constantly stirred by an iron rod. The mass gradually cools, and in so doing, a kind of crystallization takes place, crystals of solid lead falling to the bottom, from whence they are taken out by a strainer or colander. These crystals contain less lead than the remaining portion, and by this means the silver becomes condensed in a smaller quantity of lead, or, in other words, the lead remaining after the crystals are removed is richer in silver than it was before. Over and over again is this process repeated; one portion after another of the lead being crystallized, and all the cystals being made to give up their silver in a similar way, until at length the lead remaining is twenty times as rich in silver as it was originally. This point being attained, the whole remaining body of the lead, with the contained silver, is made to undergo the process of "cupellation." The lead is put into a furnace of peculiar shape, and exposed to a very high temperature. A current of air is thrown in by a blast, and the oxygen thus supplied combines chemically with the liquid lead, and forms "litharge," or red-lead; the litharge forms a scum or coating to the fluid mass beneath, and the silver is by this means gradually separated from the whole of the lead. The metallic lead is re-obtained from the litharge by exposing the latter, mixed with coal, to the action of an oven by which the carbon of the coal combines with the oxygen of the litharge, and sets the metallic lead free. It will thus be seen that chemical changes of an interesting kind are involved in the extraction of the silver from the lead.

Some of the circumstances connected with the lead-mines of Derbyshire and the north are curious. There is abundant evidence that these mines were known and worked during the Roman occupation of Britain. There are in the British Museum several pigs of lead which were found in Derbyshire, and which appear to have been made by the Romans: these are represented on a former page (Figs. 1008, 1009, 1010). One of them is twenty-three inches in length at the bottom; twenty upon the upper surface; four inches in depth; and has a weight of a hundred and fifty-four pounds; it is inscribed with the name of the Emperor Domitian, and has a date which corresponds to the year 81. One of the remaining two has the name of the Emperor Hadrian on it, and the other has a longer and rather illegible inscription. Of these pigs of lead it has been said that they "afford undoubted evidence that the lead-mines of Derbyshire and its neighbourhood were worked in the Roman time. The mines of Britain, in the earlier part of the Roman time, were worked by the subdued natives. Galgacus, in his memorable speech, preserved by Tacitus, when laying before his soldiers the consequences of defeat, mentions tributes, *mines*, and the rest of the penalties of slavery." The mine called "Odin's Mine" (Fig. 1102) is believed to have been worked ever since the time of the Romans; it consists of two horizontal levels or galleries, the upper one of which serves as a channel for bringing away the ore from the mine, and the lower one for drainage; the workings have been carried above a mile into the heart of the mountain.

In some of the Derbyshire lead-mines, belonging to the Crown, a singular code of laws is in force. There are officers, called "bar-masters," who hold mineral courts for deciding all matters relating to duties, wages, and agreements arising out of the lead-mining. Some of the customs are very singular, and date their origin at a very remote period. Upon any one discovering a vein of lead-ore, and wishing to claim it, he makes a cross upon the ground as a mark of possession, and gives notice of the fact to the "bar-master" of the district. This officer receives the first measure or "dish" of ore, as the King's representative; and the discoverer is then entitled to proceed in the exploration of the vein, under singular regulations. He works a "meer" or measure of twenty-nine yards in length; and the bar-master takes the next half-meer, of fourteen yards and a half beyond it. This half-meer is valued by experienced persons, and sold—sometimes to one person, and at others to a party or gang. Besides the share given to the Crown, the miner is also bound to give up every twenty-fifth dish or measure of ore, which is called the "King's Dish." It matters not what the size of this measure is, for the ratio which comes to the King is the same. In some districts the standard dish is a rectangular box, twenty-eight inches long, six inches wide, and four inches deep, capable of holding fourteen Winchester pints; in another district the dish is rather larger, holding sixteen pints. One of these standard dishes is represented in a former page (Fig. 1024). A small share of the ore goes to the lord of the manor, and another small portion for tithe; but these, as well as the King's duty, are compounded for by a money payment.

Very stringent laws were made in past times as to the mode of working the "meers" belonging to different persons. The mines were worked open, by removing the surface-soil, and digging down till the veins of ore were arrived at. Windlasses, called "stowses," were erected over these open workings, for drawing the ore to the surface; and every meer had thus its "stowse." The owner of the surface land was prohibited from interfering with these openings. In process of time, as the workings became deeper, the owners of several contiguous meers joined interests and worked their property in common; having one large shaft to bring up the whole produce to the surface. Still, to preserve the rights of the miners to an entrance from the land above, each meer-holder put up a small model of a windlass over his meer. It has been observed, that "even now this custom is so rigidly enforced, that a mine on which steam-engines and gins are erected is not held to be legally occupied, except one of these pigmy memorials of the ancient mode of drawing ore is constantly kept in "sight of all men." The mining laws punish by fines all persons detected removing the bar-master's stowses, even if placed in the middle of a cultivated field, a common, or a fence-wall. These models, to be legal, must have no nails in their structure, as primitively made. The bar-master charges a small sum for these shams, and the miners are obliged to be particular in replacing them when broken or destroyed."

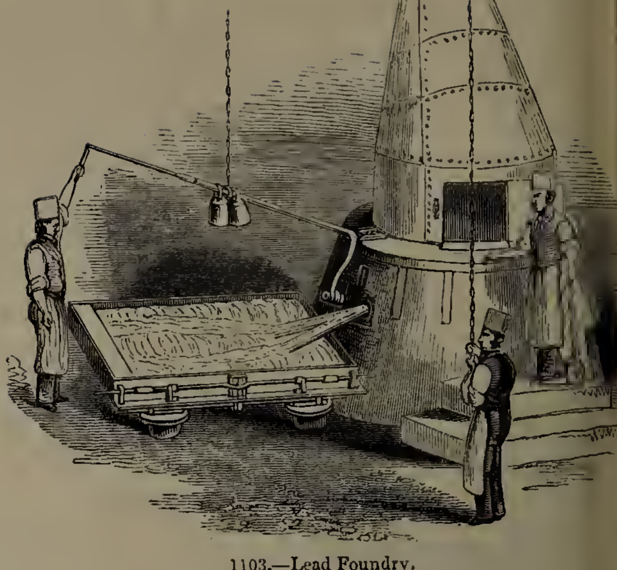
Manufacture of Lead Sheets, Pipes, and Shot.

Nearly all the articles made of lead, with which we are familiar, are made from the "pigs," resulting either from the smelting or the refining processes. *Sheet-lead* is one of the most valuable among the number: this is made either by casting or by rolling from pig-lead. The pigs, which are about three feet long by six inches wide, and weigh about 1½ cwt. each, are thrown into a furnace to be melted, and the molten metal is then made to flow out upon a flat surface. Under the old method of making sheet-lead by "casting," the metal was poured out upon a flat and very even stone table covered with sand: a roller being passed over it to equalize the thickness of the metal in every part—as in plate-glass casting. But in the modern way of producing sheet-lead by "milling," the arrangements are as follow:—The pigs of lead are thrown into a large iron cauldron or melting-pot, capable of containing ten or twelve thousand pounds of lead. A fierce fire is kindled beneath the cauldron, and a conical sheath or chimney carries the fumes up to the open air without allowing any of them to mix with the air in the casting-shop. On one side of the furnace is a cast-iron frame or mould, consisting of a flat vessel six or seven feet square by six inches deep. When the metal has become perfectly melted, and all the impurities and dross collected at the surface, a valve is opened at the side of the furnace, and the whole of the glittering, silvery-looking contents pour out (Fig. 1103) and speedily fill the mould, leaving the dross behind in the furnace. A man draws the edge of a board over the liquid metal, as a means of removing an oxide or scale that forms upon its surface, and then leaves it to cool.

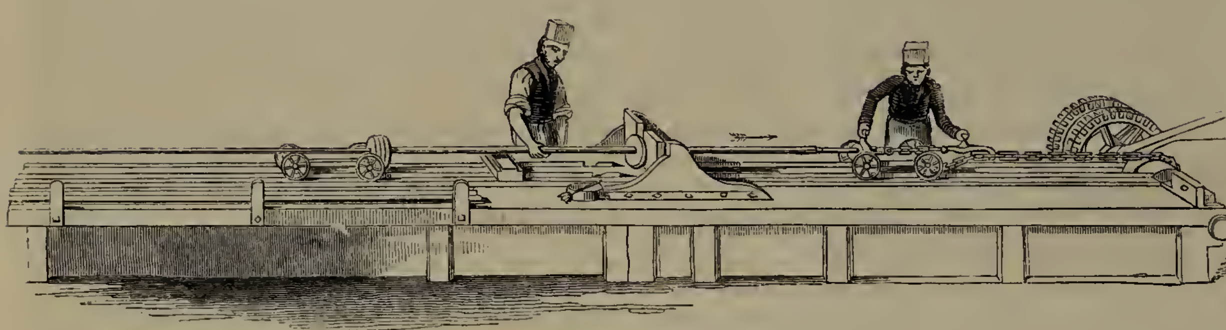
When the ponderous mass of lead has solidified and cooled, it is lifted out of the mould by means of a crane, and is subjected to a series of rollings, which bring it to any required degree of thinness. This rolling is effected by means of a machine of great beauty and power (Fig. 1104). It consists of a long frame sixty or seventy feet in length, by eight in width, standing at a height of three or four feet from the ground. Transverse rollers are placed parallel along the whole length of this frame, at intervals of about a foot apart. In the middle of this frame is the "milling" apparatus, consisting of two rollers of immense power: they are made of iron, have a diameter of about sixteen inches, and weigh three tons each. These rollers are placed at a distance apart about equal to the thickness of the large plate of lead, one over the other. The lead is lifted upon the frame by means of a crane, and is passed between the rollers, by which it becomes slightly reduced in thickness and increased in length. It is passed to and fro between the rollers time after time; the rollers being, by adjusting mechanism, brought a little nearer together after each rolling; until at length the plate of lead is spread out to the full length of the frame. The lead is then cut in two, and each half is rolled again and again, until the increasing length renders it necessary to make a further section. So the operations go on, until at length the lead is reduced to the thickness required. The lead passes between the rollers seven or eight hundred times, having its thickness lessened each time. The moving power is given by a steam-engine, and the wooden rollers enable the lead to traverse to and fro along the frame.

The fashioning of sheet-lead into useful forms need not engage our attention, since it involves very few operations other than those of cutting and soldering. The making of *pipes* is, however, a separate and a curious matter; requiring, like the production of sheet-lead, a combined process of casting and compression. A piece of pipe is in the first instance cast, from two to four feet in length, having an internal diameter

1102.—Entrance to the Mine of Odin, an ancient Lead-mine in Derbyshire.



1103.—Lead Foundry.

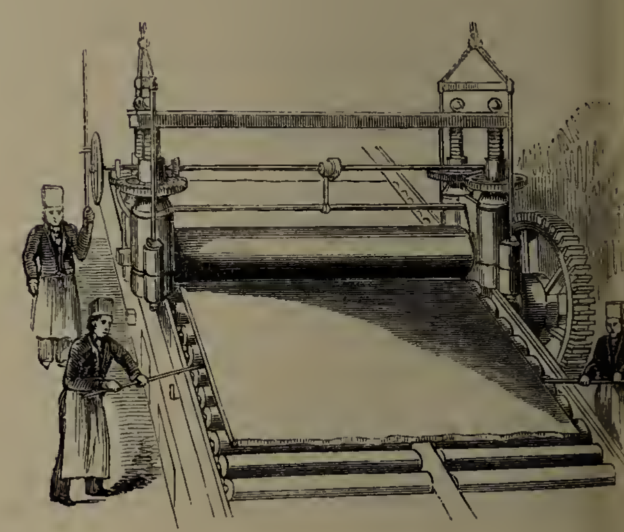


1105.—Drawing-bench or Lead-pipes.

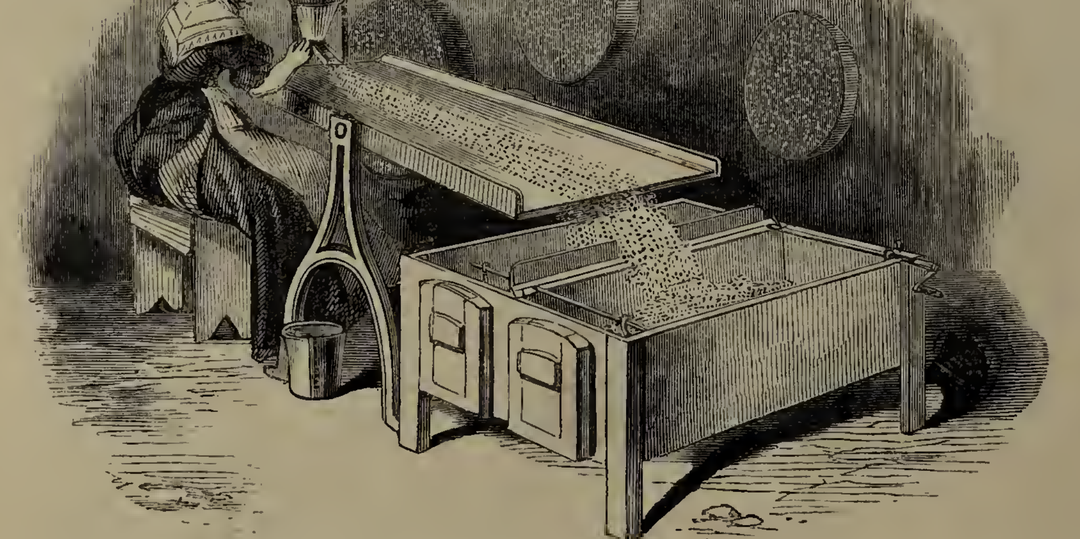
1106.—Casting Shot.

1108.—Egyptian Nose-rings.

1109.—Egyptian Ear-rings.

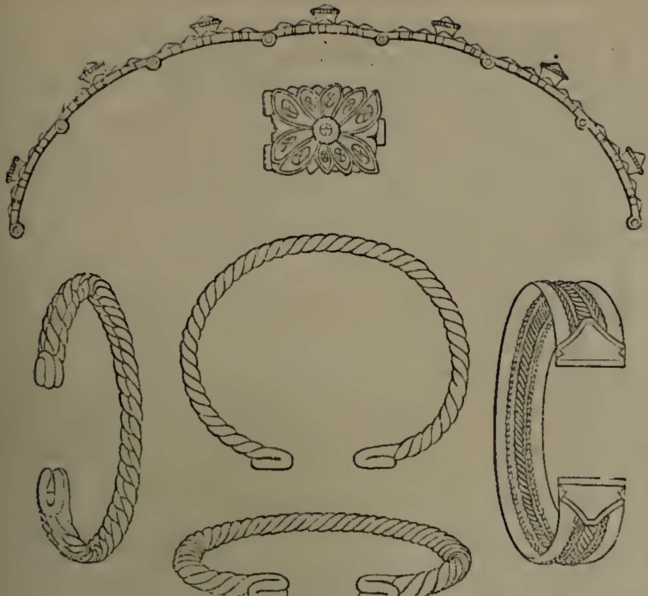


1104.—Lead-rolling Mill.



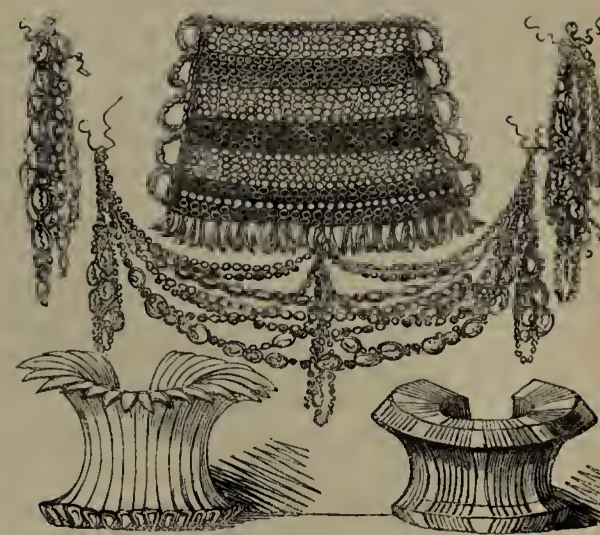
1107.—Inclined Plane for separating Shot.

1110.—Ancient Egyptian Spoons.



1111.—Egyptian Bracelets.

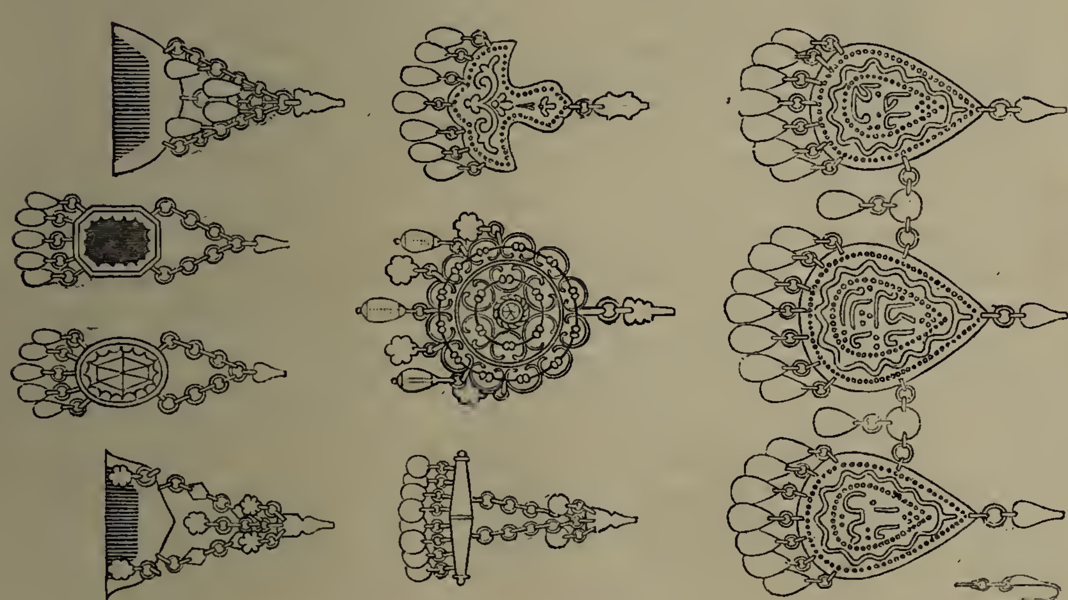
1112.—Silversmith at work. (From an Ancient Egyptian Painting.)



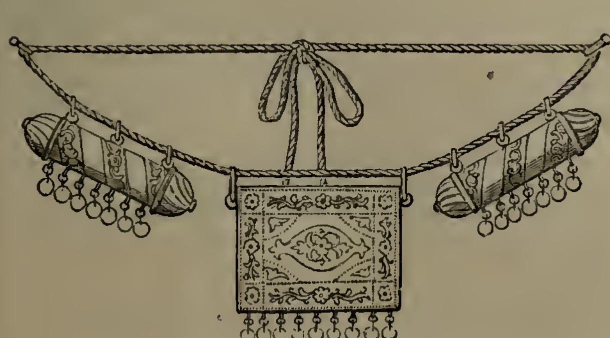
1113.—New Zealand Bracelet and Ornaments.

1114.—Egyptian Jewellery.

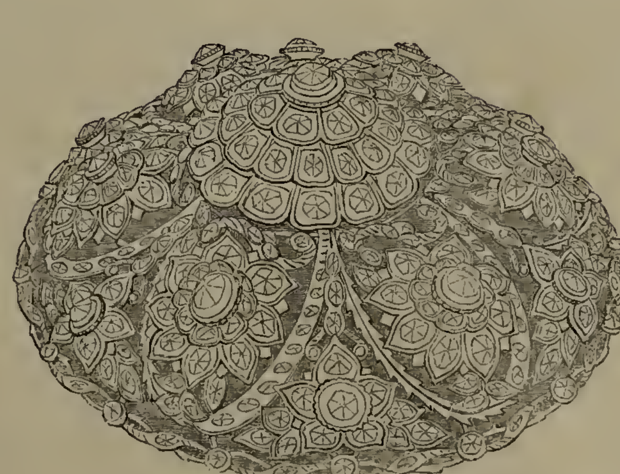
1119.—Gold-washing in Brazil.



1115.—Egyptian Jewellery.



1116.—Egyptian Jewellery.



1117.—Egyptian Jewellery

1118.—Egyptian Jewellery.

equal to the intended bore of the pipe, but with an external diameter very much greater, owing to the thickness given to the metal of the pipe. The mould in which these lead pipes are made consists of a frame (Fig. 1101) holding a mould, or two semicylindrical halves, with a spindle or core running down the middle, to form the bore of the pipe. The mould is set upright; and when the lead is melted, it is poured by a ladle into the cavity of the mould. On the solidifying of the lead, the two hinged halves of the mould are opened, and the short pipe, called technically a "plug," is removed from it.

To elongate this plug is the next process; one effected by means of the "drawing-bench" (Fig. 1105). This consists of a frame about thirty feet long, having a vertical stand in the middle. This stand contains a hardened steel plate, with a hole in the middle equal to the external diameter of the pipe; or rather, there are many such plates, with the holes diminishing gradually in size according as the process advances. One of the "plugs" of lead has a steel mandrel or rod passed through it, and is drawn forcibly through a hole a little smaller than itself, by means of a carriage and chain worked by a steam-engine. Time after time the plug is thus drawn, the plate being changed after each drawing, in order that the hole may correspond with the diminished size of the pipe. In fact, the principle is just the same as that of wire-drawing, with the exception of the arrangement for keeping the internal bore of the pipe open. The "plugs" are cast originally with an internal diameter varying from half an inch to four inches, and with an external diameter varying from two to six inches. In producing a two-inch pipe from a "plug," there are sixteen dies or draw-plates used, the holes in which are all of different diameters.

There is one department of the lead manufacture remarkable both for the processes followed and for certain events in the past history of the operations, viz. *lead-shot*. These little missiles of destruction are of various sizes, but they all require to be made as exactly spherical as possible; and the attainment of this sphericity has been an object of much solicitude and difficulty. A primitive mode of making shot was to cut up sheet-lead into narrow strips, and these strips into little bits; then, placing these small pieces out on a flat stone, another stone was laid upon them, and worked about until the fragments of lead were rolled to something like a globular form. Another method was to shake a number of small bits of lead together in a bag, whereby they mutually rubbed down each other's sharp edges and corners. A better mode, for producing shot of a larger size, is that of *casting*. For this purpose a mould is used, formed of two oblong pieces of brass hinged together at one end. In each half are several hemispherical cavities, so arranged that when the mould is closed the cavities form spherical hollows just the right size and shape for the shot. Small channels are left open to communicate with these cavities; and melted lead is poured through the channels till the cavities are full. On opening the mould the shot are extricated, and are soon finished by cutting off the asperities of the surface.

The mode of procedure now adopted, however, is totally different from both of the former. It is a mode by which the lead is made to separate into drops, and these drops to solidify before they lose their spherical shape. The origin of this method is, if true, a very odd one. "A plumber of the name of Watts, residing in Bristol, in the year 1782 obtained a patent for the manufacture of shot by a mode which is said to have been suggested to his mind in a dream; this mode was to pour melted lead from a considerable height, so that, in falling, it should cool into separate globules or shot. He made an experiment from the tower of the church of St. Mary Redcliffe, at Bristol, which was satisfactory. He afterwards succeeded in disposing of his patent to the firm of Walker, Maltby, and Co., for 10,000*l*. With this sum he projected the formation of a crescent on so grand a scale, at Clifton, that he spent the whole of the money in making excavations and foundation-walls, which afterwards obtained the expressive name of 'Watts's Folly.'"

The mode itself, whether its origin be or not correctly given thus, is now followed generally, and is thus managed:—There must be a vertical space of one or two hundred feet, through which the shot must fall in the course of cooling; and some manufacturers obtain this descent by building a lofty tower (such as the one near the foot of Waterloo Bridge), and conducting the operations at the top of it; while others dig a pit, or make use of the vertical shaft of a neglected coal-mine, and conduct the operations at the surface of the ground. Supposing the latter plan to be adopted, there is a trap-door laid over the pit, closing it over with the exception of a circular space half a yard in diameter. Over this space is placed a stand, capable of holding a kind of colander or iron pan, pierced with small holes: different pierced vessels are used, with holes varying from one-fifth to one-thirtieth of an inch in diameter, according to the size of the shot to be made. On the bottom of the pierced vessel a layer of dross from the lead furnace is placed, to act as a kind of filter before the lead enters the holes. Near this apparatus is a small furnace, where the lead is melted, a little arsenic being added to the lead to harden it. When all is ready a man ladles the molten lead out of the furnace, and pours it into the colander (Fig. 1106), from the holes of which it speedily descends as a glistering shower of drops. These drops pass into the entrance of the pit, and fall through a depth of two hundred feet, where they are received in a vessel of water. A good deal of judgment is required in giving a spherical instead of a pear-like shape to these drops: the composition and temperature of the metal, the filtering medium in the colander, and the depth of the descent, all have influence on this point.

When the shots are brought up from the bottom of the pit (to effect which men are lowered by means of a windlass) they are dried on steam-heated iron plates, and separated into sizes by sifting. They are then made to fall in a stream on a sloping table (Fig. 1107), along which they roll till they fall into a receptacle near the lower end. In doing this a curious result is brought about. All those shot which are any way defective in form (and with all the care bestowed there must be some such examples) roll down less steadily and quickly than the perfectly round ones; the consequence of which is that they have less impulsive force when they get to the bottom, and drop nearly vertically in a box beneath. Those shot, on the contrary, which are well rounded, have force enough in their descent to spring from the table to another box, a little farther removed; so that the good are separated from the bad by these means. In this simple but beautiful contrivance, the angle at which the table is placed is made to depend on the size and quality of the shot; and so nice is the adjustment, that almost every defective shot is separated from the rest, to be re-melted.

The shot are revolved in a barrel containing a little black-lead, by which they have a glossy blackness given to them; and they are finally tied up in bags for market.

GOLD, SILVER, AND THE SCARCER METALS.

Having thus glanced rapidly at those metals which play the most active part in the everyday operations of life; these without which man would hardly have been other than a savage—we may now pay a little attention to those which are grasped at more greedily than all, viz. *gold and silver*. It is a matter of no small difficulty to convince ourselves that these are really less valuable to us than iron. So uniform is the custom of regarding gold and silver as identical with wealth, that we fancy wealth can only be where gold and silver are: that a man whose warehouses may be stored with iron is not wealthy unless his bank is also stored with gold. If a country were totally isolated from every other country, and had both gold and iron among its mineral treasures, it would soon be found that the iron effected more than the gold in advancing the prosperity of the country. Or, still further, if two countries were equally isolated from each other and from all other countries; and if one produced iron without gold, and the other gold without iron, it would not be hazarding too much to say that the former (other things being equal) would rise to eminence and wealth long before the latter.

But however this may be (and the matter is rather an intricate one to touch upon), it is sufficient for our present purpose to know that gold and silver are important agents in the arts, and that the manufactures connected with them are influential and extensive.

The use of Gold in Ancient Times.

Whatever may have been the source whence the ancients obtained their gold, there is abundant evidence that this metal was admired and valued by them much as it is at the present day. Many of the accounts given in early writers dazzle us into the supposition that the stores of gold in those days were much larger than can be commanded at present. Thus Semiramis is said to have erected statues of Jupiter, Juno, and Rhea, forty feet in height, and made of beaten gold. Drinking-vessels made of gold, and weighing twelve hundred talents, are also spoken of. The sumptuous displays of precious metals in the palaces of the great were frequently alluded to; but it has been aptly observed that the quantity diffused among the bulk of the English population at the present day would make a sum total far outbidding the golden wealth of those earlier days: though less obvious and glittering from being so much more diffused.

The ancients appear to have obtained their supply of gold from Asia. Mention is made, in some of the early writers, of a people living near the source of the Indus searching for gold. Alexander the Great brought a large store of gold away with him on his return from the East to Europe. The Persian provinces through which he passed presented, in their chief cities, vast stores of gold and silver, if we are to believe the account given of them. Thus, at Ecbatana, the palace was "so magnificent in every part, as to give a high idea of the power and wealth of those by whom it had been erected; for though the wood of it was all cypress or cedar, no part of it was left naked; yet the beams, the roof, and the pillars that supported the porticoes and peristyles, were all covered with plates, some of silver and some of gold. The tiles, likewise, were all of silver. Though the place had been three times plundered, there still remained, in the temple of Ena, some pillars cased with gold, and a large quantity of silver tiles laid together in a heap. There were also some few wedges of gold, and a much greater number of silver."

Mr. Jacob, in his 'History of the Precious Metals,' gives some curious illustrations of the use of gold in the arts—not because it was fitted for the purpose to which it was applied, but that the persons who used it had more gold than iron at their command, and would in all probability gladly have changed their gold, weight for weight, for iron:—"When Brazil was first discovered by the Portuguese, the rude inhabitants used fish-hooks of gold, but had no iron, though their soil abounded in that metal. The people in Hispaniola and Mexico were in like manner unacquainted with iron when first visited by the Spaniards; though they had both ornaments and implements of gold, and weapons of copper; which latter, as we learn from the analysis of Humboldt, they had acquired the art of hardening by an alloy of tin. This subject has been illustrated in Denmark, by opening many Scandinavian tumuli of very remote ages, from which have been collected specimens of knives, daggers, swords, and implements of industry, which are preserved and arranged in the Museum at Copenhagen. There are tools of various kinds formed of flint or other hard stone, in shapes resembling our wedges, axes, chisels, hammers, and knives, which are presumed to have been those first invented. There are swords, daggers, and knives, the blades of which are of gold, whilst an edge of iron is formed for the purpose of cutting. Some of the tools and weapons are formed principally of copper, with edges of iron; and in many of the implements the profuse application of copper and of gold, when contrasted with the parsimony evident in the expenditure of iron, seems to prove, that, at the unknown period, and among the unknown people that raised the tumuli which antiquarian research has lately explored, both gold and copper were much more abundant products than iron."

Various countries show evidence of the use of gold in great quantity at a time when, in other respects, they must have been in a very barbarous state. In Ireland, for instance, scarcely a year passes without some golden relic being dug up or discovered in ancient buildings or ruins, such as corslets, bridles, chains, rings, bracelets, &c.; and almost every private collection of antiquities in Ireland contains some or other of such specimens.

Gold Mines and Mining.

Gold is found in many different parts of the globe, but chiefly in America. The central districts of Siberia, or Asiatic Russia, near the Ural and Altai Mountains, yield gold; and it is curious that there are here indications of mining operations, as carried on at a very remote period, long before we had any historical knowledge of the Siberians. Mr. Jacob gives the following account of these ancient gold-mining works, as brought to light by recent travellers:—"The extent of the works show that the workmen must have been numerous; whilst an inspection of them proves that only the first rudiments of the science of mining could have been known to them. Besides some implements the use of which is unknown, there were wedges and hammers, all of copper, that had been smelted, but without any particles of gold in them. Instead of sledges, they seem to have used large stones of a long shape, on which are to be seen marks which show that handles had been fastened to them. They seem to have scraped out the gold with the fangs of boars, and collected it in leather bags or pockets, some of which have been found. With such imperfect implements, the work of excavation must have required the labour of a great number of hands for a long time, and in some cases must have exhausted their patience. In one instance, after having proceeded to some depth, and reached a bed of hard stones, the work, after penetrating a little way, had been abandoned. Some of the pits are twenty fathoms in depth, shaped like a well, and are about seven feet in diameter. The passages and props are well executed, but the former so narrow and low that it must have been difficult to have worked in them. The natural pillars left to support the roof are in some instances still effectual for that purpose, and in these are still found small portions of copper-ore, containing particles of gold; in other instances the supports have given way, and in them are found some human bones, probably of those who had been buried in the ruins. That a great number of people were employed is inferred from the numerous fragments of earthenware which are found scattered to a great distance around. It appears that only the richest ores were worked, and some of them must have been smelted in the mines; for in the rubbish of one of the supports that had fallen in, there has been found melted copper, and the implements for smelting it; some of these implements also have been found on the surface near the pits. The operation of crushing as well as washing the ores was

performed in the rivulets, and, as is supposed, the latter was omitted in the rich ores, which were found on elevated spots. The smelting, whether in the mines or on the surface, was performed in small furnaces, of which Gmelin observed near a thousand in the eastern parts of Siberia. They were made of red bricks, and in them pieces of melted copper, from two to three pounds in weight, have been found. The height and breadth of these furnaces were about two feet, and the length three feet."

The Siberian mines of the present day are an object of much attention on the part of the Russian government. Nearly all the silver found there is the private property of the emperor; but the gold-mines are owned more frequently by private individuals, who are, however, brought into communication with the government before the precious metal can be applied to profit. The arrangements assume something of the following form:—It is open to any free man in Russia (except a government official) to search for gold deposits in any part of the territory; and when a discovery of gold-ore has been made, the discoverer announces the fact to the nearest government official. From him application is made to the nearest mining department; and an officer is sent to measure out a space of five square versts (a verst being equal to three-quarters of an English mile), which is given up to the adventurer. The latter proceeds to erect huts for the workmen, and buildings for washing and preparing the gold. The condition on which he receives the land is, that he must take all the gold he procures to a government depôt, in the autumn of each year: here the gold, consisting of lumps, grains, and dust, all mixed together in bags, is weighed, registered, and cast into ingots; it is then assayed, to determine the ratio of pure gold contained in it. When these preliminaries are completed, the gold is sent to St. Petersburg, where it is coined into money, and the proceeds paid to the speculator, with a deduction of fifteen per cent. for the expenses incurred by the government throughout the operations.

The miners or workmen employed by the speculators are chiefly persons who have been banished from Russia, and who receive from the police a stamped permission to reside on the spot for the term of one year; the permission being renewable at the end of that period. Some of the establishments formed by the speculators are situated two or three hundred miles from any large town; so that flour, meal, fish, and other provisions have to be conveyed on horseback; there being frequently no made road between the two places. The expenses are thus very large, and a speculator frequently finds that his enterprise is a losing one; since, unless the ore be rich in gold, the outlay will be greater than the value of the produce. Mr. Cottrell, who has recently published an account of a journey to these districts, gives the following illustration of the precarious nature of the gold-mining speculations:—In 1829, a merchant of Tomsk, named Popof, heard accidentally that a deserter, concealed in the woods about a hundred miles from that town, had found gold in the sand. Popof found means first to identify the spot, and then to obtain a grant of it from the government. At first he was not very successful, the produce being only about half a *zolotnik* to a hundred poods of sand (equal to a proportion of about one part of gold to four hundred thousand of sand). He abandoned this spot, and removed his establishment more than a thousand miles northward of Tobolsk: here he found gold, but not in greater quantity; and as the soil there is constantly frozen, the expense was very great, independent of the difficulties attendant on the scarcity of horses, workmen, and provisions. After having spent in all sixty-three thousand roubles, and searched in no fewer than three hundred different spots, he returned to the place first selected, and succeeded better than before.—Another example was afforded by a M. Astaschek, who, being an official in the government service, resigned his office in 1832, in order that he might commence gold-mining. Popof, the merchant just spoken of, lent him forty thousand roubles to begin with. Astaschek met with a person who had spent two hundred thousand roubles fruitlessly in the search of gold; and the two joined interests. They succeeded in discovering gold in the sand on the banks of a small river—just in time to save Astaschek from bankruptcy, for he had spent thirty-five thousand roubles out of the forty thousand which he had borrowed, before he reached any return for his capital. When once the good discovery was made, however, the fortunes of the speculators rose rapidly, insomuch that in the year 1841 M. Astaschek was reputed to be a *millionaire*.

Smelting and Washing the Gold-ore.

A description of the American gold-mines will be best given by following the modes adopted for bringing the metal to a pure state.

Gold is not found mixed with so much earthy matter as most other metals. It occurs in the metallic state —not, however, pure, but combined with some other metals, such as silver, copper, or iron. Sometimes this compound metal is found in veins in the primary or older rocks. By far the largest portion, however, occurs in alluvial soils or sands, where the gold is found in grains, scales, and lumps; these are mostly rounded at the angles, so as to afford evidence that they have been derived from pre-existing rocks, where the gold occupied veins which traversed the hard stone. It is supposed that the substance of the rock had become worn away by the action of the atmosphere through a long series of ages; and that the gold broke up into fragments, which mixed with the sand and alluvial soil on the banks of rivers, in the valleys between or among the mountains where the veins had occurred.

An account of the processes adopted in Brazil, as described by M. Rugendas a few years ago, will suffice for America generally. According to the mining laws of that kingdom, when a person discovers a district rich in gold, he obtains from the government a portion of the land sixty fathoms in length by forty in breadth, which he is allowed to call his own; the government claims a second portion of equal size, and usually farms it out to other persons; and a third portion is appropriated in a way supposed to be best suitable for the efficient working of the whole, according to the number of slaves that can be collected on the spot. There are three methods of mining adopted, which may illustrate the matter generally.

In the first method, the mountain containing the gold is pierced in various quarters until a vein is found; and this vein is worked as long as it remains profitable. The excavations are seldom very deep; and as soon as the vein becomes too poor to pay for further excavation it is abandoned, and another one sought at another place; so that the mountain becomes by degrees quite honeycombed. The gold sought for by this mode is nearly pure, and requires very little subsequent operations.

In the second method, streams of water are made by conduits to flow over the beds impregnated with gold. The violent descent of the water tears up the soil, and carries it down the slopes of the mountain-sides to the valleys at the bottom. Slaves, furnished with spades and levers, aid in this operation, by rending from the side of the hill the large masses which the waters may have loosened. All the masses and fragments thus collected together are broken up, and whilst the water, sand, and gravel are made to flow off through narrow channels, the harder masses are stopped by a guard or grating. While thus flowing on, the water is stirred most assiduously by slaves, in order that the small particles of gold may be separated from the sand and gravel, and fall to the bottom, where they are received on hides or on woollen clothes spread out for their reception. These clothes or hides are dried, and are then well beaten to liberate the little fragments of gold. This constitutes the whole of the method; and a very wasteful and inefficient one it is: for a number of the smaller and less weighty particles are carried off by the rapidity of the current without being deposited at all; while all the gold which is contained in larger masses of rock detained by the grating is neglected. In Fig. 1119 are represented several stages in this mode of proceeding.

In the third method, advantage is taken of the waste which occurs in the other two; and it is adopted by negroes and poor persons, who are permitted to employ themselves in this way if they so please. The rejected or neglected pieces of rock, which nevertheless contain gold, are carried down into rivers and streams, which also have a good deal of minutely divided gold in their waters, arising from the circumstance just alluded to. The "faiscadores" (as the poorer class of adventurers are called) wade into the water up to their waists, and dip up the sand or wetted soil in wooden bowls: they shake these bowls in such a way as to cause the golden particles to sink to the bottom, and the earthy and lighter particles to float at the top. By this means, and also by washing a collected heap of sand on the river side, the "faiscadores" find gold enough to pay them for this expenditure of their time.

All the gold thus procured is sent to the imperial foundry to be smelted or purified. Two plans are adopted for this purification in different countries, viz. *amalgamation* and *cupellation*. In the first of these the action depends on the chemical relations existing between gold and mercury. When the gold is separated as much as possible from impurities by washing, quicksilver, salt, and water are added to it; the mixture is well beaten and shaken together, and kept at the temperature of boiling water for some days. The gold and the mercury are thus made to combine; and all the rest being separated from it by washing, the two are distilled in an alembic or still, by which the mercury passes off in the state of vapour, and the gold is left remaining in the metallic state. If the gold now contains a small quantity of silver or of copper, which is frequently the case, the separation of these would require a further process. In the other mode, that of *cupellation* (adopted principally in the gold-mines of Hungary), the process depends on the property possessed by copper (usually contained in the ore) of attracting oxygen from the air when exposed to a strong heat, and of being thus separated from the gold. The ore, as dug out of the ground, is first well roasted to drive off the sulphur or other volatile matters which may be contained in it. By successive meltings the metals contained in the ore are separated from all the earthy particles; and arrangements are then made for separating the gold from the copper, lead, or other coarser metals. The compound metal is put into a crucible made of bone-ashes, and called a "cupel." A strong blast of intensely heated air is made to pass over the surface of the melted metal in the cupel, by which the baser metals are converted into oxides, which are either skimmed off from the surface or absorbed by the porous texture of the cupel. By these means the gold is gradually separated from all the other constituents of the ore.

When the Brazilian gold has been purified by fusion, it is made up into ingots of different dimensions, assayed, marked, and one-fifth retained by the government as its share. The bars of gold are then given to the proprietor, with a detail of the operations to which the metal has been subjected; and it is only from that moment that the bars may be employed in the commerce of the country, or used for exportation by the special permission of the government. When it is wished to exchange ingots for coin, this is effected through the medium of the government. The orders for the supervision of the gold-mining operations are as strict as they can be in an ill-regulated country; but the government share of twenty per cent. is sufficient to induce smuggling, which is believed to be carried on to a large extent.

The mining operations in Siberia, to which we have already alluded, bear more relation to those of the Faiscadores of Brazil than to those of Hungary. The gold is not found in a mine, or combined with masses of rock; the sand of the district is collected, and by careful washing is found to yield grains and small fragments of gold, which are separated from the sand. Some of the plains in the region inhabited by the Kirghis Tartars are found occasionally to contain gold among the sand: in such cases a speculator hires the spot from the Kirghis at a fixed yearly rent; and whenever he discontinues his operations the land reverts to the owner, who finds it in a more cultivable state from being deprived of its gold.

Jewellery and Ornaments of Gold.

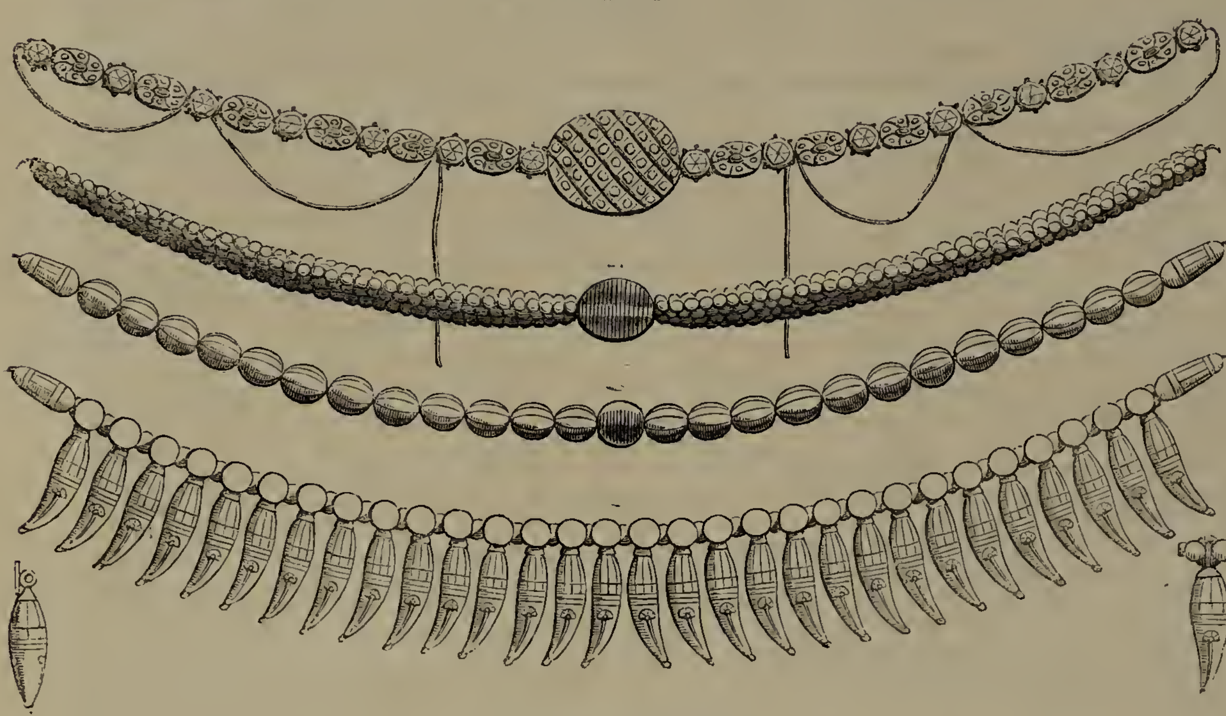
The details above given will show that, in many respects, the preparation of gold in a metallic form is less difficult than that of most of the ruder metals. The gold combines less readily, and with less chemical intensity, with the earthy components of the rocks in which the veins occur; and it therefore submits to the separating processes with more readiness. Its great value, too, renders a search for minute particles profitable, under circumstances which could not possibly answer favourably with a metal of less commercial price.

The fabrication of personal ornaments and articles of luxury from this metal is carried on very extensively in our own day. Many such articles are made of solid gold, whereas others are formed mainly of some cheaper material, coated on the surface with gold. *Gold-lace* may be regarded as a striking example of the latter kind; since it is very beautiful in appearance, and yet consists really of gold only to an extent so minute as almost to surpass belief: this can only be understood by describing briefly how gold-lace is made. Gold-lace consists of threads of silk; these threads being twisted or woven together in a peculiar manner. Every thread is bound round from end to end with a coil of gold-wire; and even this wire, so far from being pure gold, is merely an exceedingly thin layer of gold placed upon a centre or core of silver wire. In the first place, a rod of solid silver is prepared, about two feet long by one inch in thickness; this is heated over a charcoal fire, and is then covered with a coating of leaf-gold, which is burnished down securely upon it; upon this another similar coating is applied, and so on until five or six thicknesses of leaf-gold have been used, by which a thickness is attained sufficient for the object in view. The quantity of gold thus applied is not much more than a hundred grains to a pound of silver. The silver is annealed, and is then brought into the state of fine wire by a wire-drawing process very similar to that which was described in an earlier page of this chapter; it is first reduced by successive gradations from the thickness of an inch to that of one-fifth of an inch; and is then worked through holes smaller and smaller in diameter until it becomes as fine as a hair, which hair-like filament is bound round the silken thread to make gold-lace. Now this wire, no thicker than a hair, is made mainly of silver, the thickness of which is enormously greater than that of the gold that envelops it; for it will be remembered that there was in the first instance only a hundred grains of the latter to a pound of the former. It has been calculated that the exquisitely fine film of gold thus obtained on the surface of the silver-wire for gold-lace is not thicker than one-third of a millionth part of an inch!

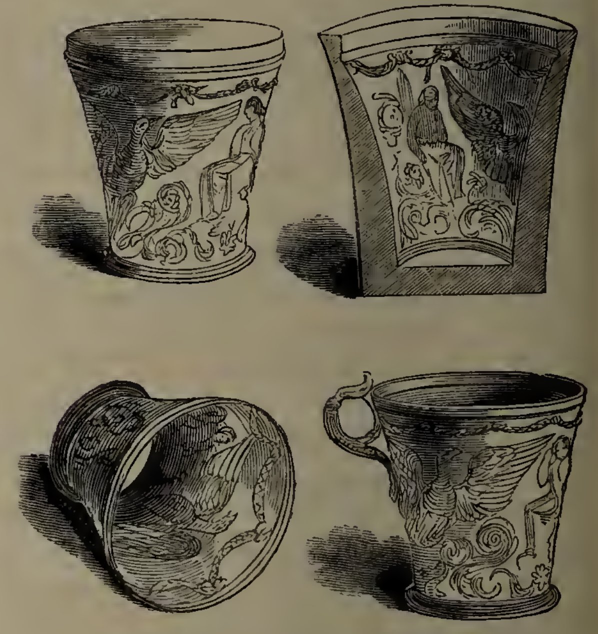
A second mode, in which a thin film of gold is made to do duty instead of a larger substance of the metal, is by the process adopted in cheap jewellery, and which is exemplified in the gilding of buttons, briefly noticed in

1120.—Electro-gilding.

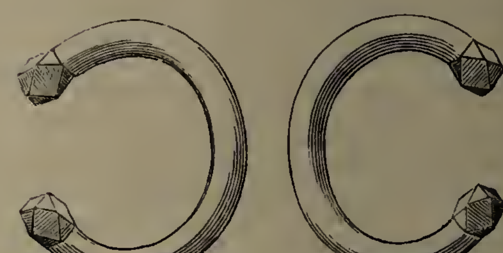
1124.—"Swaging," or Shaping Silver-plate.



1121.—Egyptian Necklaces.



1125.—Model and Moulds for Electro-plate.

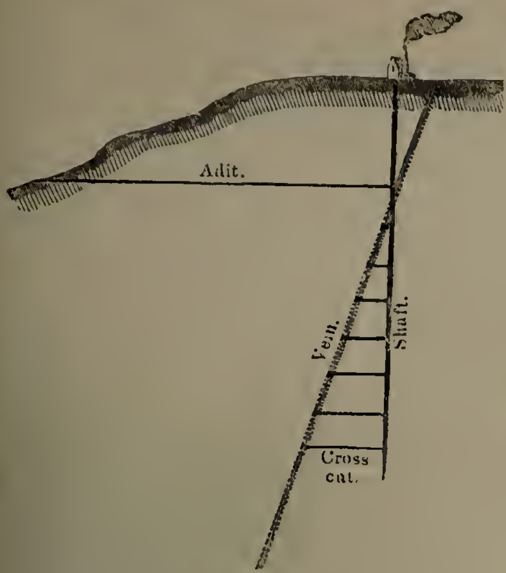


1126.—Egyptian Ankle's.

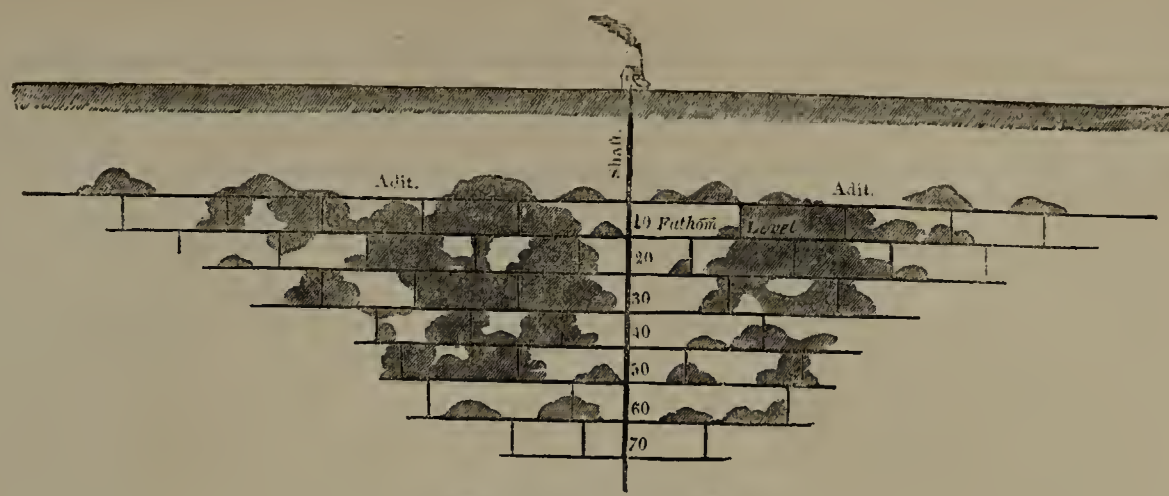
1122.—Burnishing Silver-plate.

1123.—Soldering Silver-plate.

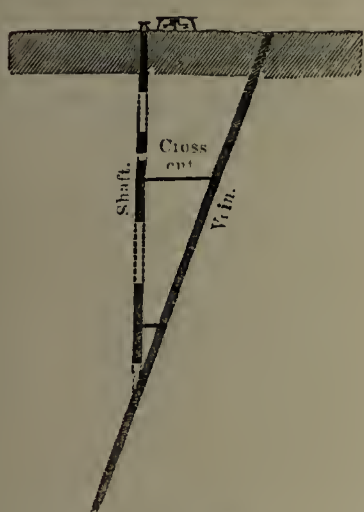
1127.—"Planishing" or hammering Silver-plate.



1129.—Cross Section, showing the progress of a shaft after cutting the vein.

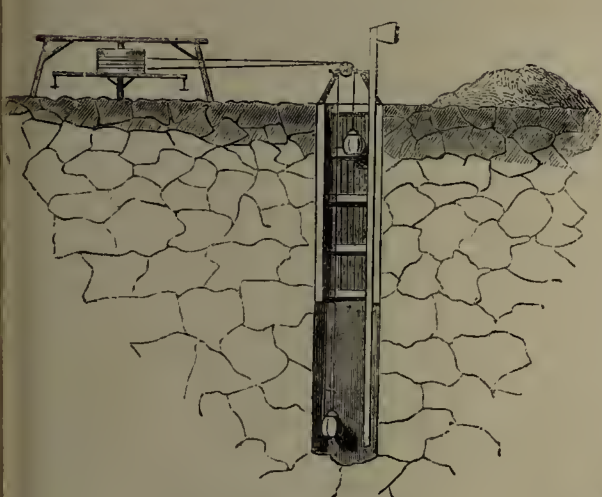


1128.—Longitudinal Section of a Mine.

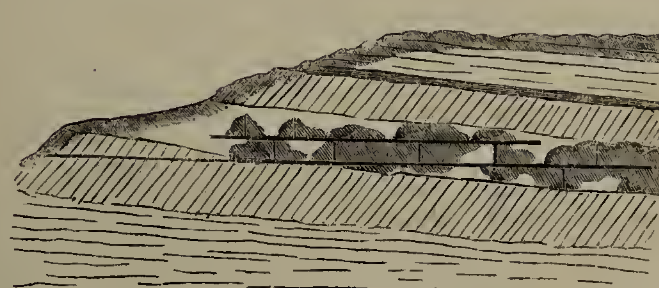


1130.—Cross Section, showing the progress of a shaft worked at several points.

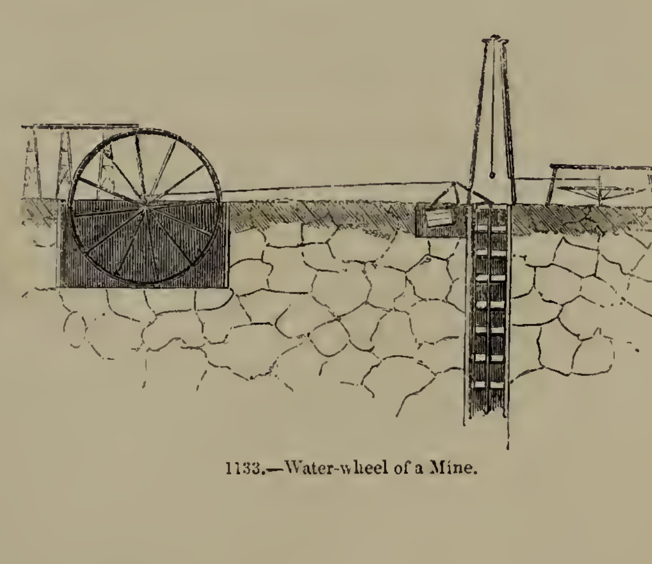
1137.—Brazilian Convoy of Diamonds from the Diamond District to Rio Janeiro.



1132.—Vertical Shaft of a Mine.

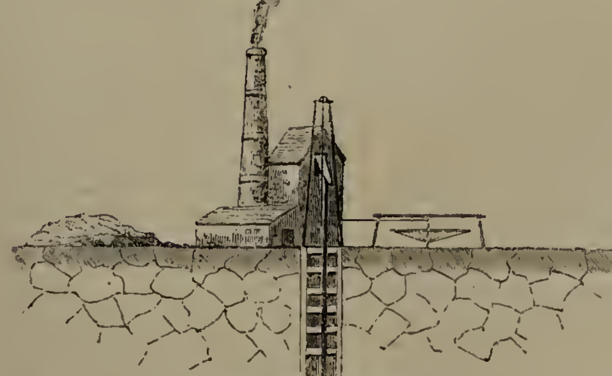


1131.—Horizontal Galleries of a Mine.

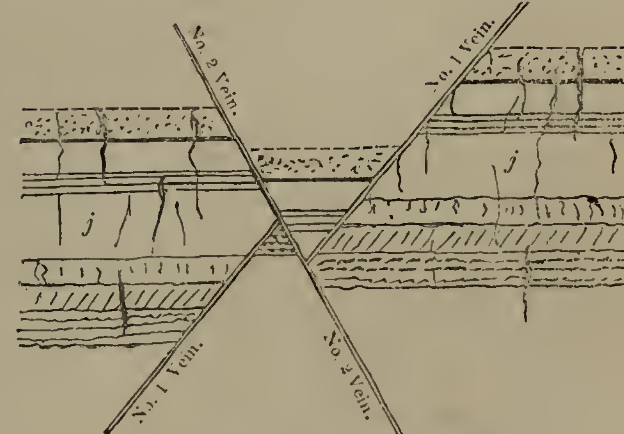


1133.—Water-wheel of a Mine.

1135.—Horizontal Gallery of a Mine.



1134.—Steam-engine of a Mine.



1136.—Metallic Veins intersecting Strata.

a former page. Here the gold is made to combine into a paste with mercury and other chemical agents: and this paste being thinly applied to the surface of the object to be gilt, a subsequent heating drives off the mercury and chemical agents, and leaves the gold in a very thin film on the surface. It is stated that five grains of gold, worth about fifteen pence, is in this way frequently made to gild a hundred and forty-four buttons, each an inch in diameter!

The beating of gold into thin leaves may be described in connexion with that of silver, a few paragraphs hence.

Jewellery, properly so called, is however an art of somewhat higher pretensions, since it involves the use of solid gold, or at least of gold having the same quality throughout the substance of the articles made. Jewellers' gold is seldom quite pure, but is combined with other metals of lower price. There is a curious set of terms employed in designating the quality of gold. In the gold coinage, for instance, as the pure metal would be too flexible to bear the hard usage to which coin is exposed, it is alloyed with a little commoner metal, to give it an increase of hardness. The English legal "standard" for coin-gold is expressed by the fractions $\frac{11}{12}$, or $\frac{22}{24}$, or by the term "twenty-two carats fine." This means that there are, to every twenty-four carats, or equal parts of the metal, twenty-two of "fine" or pure gold; the remaining two parts being a mixture of silver and copper. In goldsmith and jewellery operations, in like manner, the quality of the gold is expressed by stating the number of "carats fine" which it contains. Some jewellery is said to be made of "fine gold;" and this, if the term be correctly employed, would refer to gold really pure; but such is not the case, for it seems to imply merely the best or finest which jewellers are in the habit of using, and which contains about two-thirds of pure gold. Indeed, pure gold would not be hard enough for such manufactures. Jewellers' gold varies from this quality downwards, by indefinite degrees, and to an indefinite extent.

A writer whom we have before quoted (Mr. Jacob), while speaking of the consumption of gold in England, makes the following remarks on the jewellery manufacture:—"Without being minute observers of fashion, or without being constant frequenters of those circles in which its changes are most observable, it is impossible not to remark how great, though gradual, has been the increased introduction of gold ornaments in the decorations of females. This has been especially remarkable within the whole of the last twenty years, but perhaps much more so within the last than the first ten years of the period [this was written in 1831]. Only a junta of jewellers, dress-makers, and ladies' maids could give a complete catalogue of the numerous ornaments of gold and silver which have of late been added to the dress of our females in the higher circles of society. Ornaments for the head, including large combs of gold, necklaces and brooches of extended size, clasps and buttons of gold to fasten the bodies of the gowns, bracelets and armlets, additionally numerous rings on the fingers, gold hooks and eyes for the drapery of the gowns, eye-glasses set in gold and secured by chains of gold, and a watch with gold seals, and trinkets too numerous to be mentioned by one not professionally a master of dress. Such are the additions recently made to the application of gold to purposes of ornament."

But this includes only those instances where *bonâ fide* gold is the material of the decoration: another section is becoming, commercially and artistically, every year more and more important. "The ornaments of this kind are first fabricated of fine gold, and commonly in London alone: they are, however, soon imitated by other workmen in gold of inferior quality, in some degree of inferior workmanship, at Derby and Liverpool, but more especially at Birmingham. At the latter place much gold is so mixed with alloys, in the combination of which much chemical knowledge is applied, that it can be sold at all prices from a half to even a quarter the cost of standard gold."

The operations of the working goldsmith or jeweller consist of a minute imitation of the processes of metallurgy generally. Rolling, stamping, wire-drawing, filing, hammering, riveting, soldering, burnishing—all are followed to a greater or less extent; and all are the work of men, who confine their workshop arrangements within a very small space. The sorts of articles produced by these means are, in our own country, too well known to need description; and as to foreign countries, we may assume that wealthy Europeans generally, whether of England or elsewhere, soon copy each other's tastes in respect to these kinds of decorations. As to countries further from home, we may gather a hint or two from the wood-cuts (Figs. 1108 to 1118 inclusive; Figs. 1121, 1126). Most of these relate to Egyptian jewellery, such as Mr. Lane describes as being worn by the higher class of Egyptian females at the present day.

Silver-Mining and Smelting.

Many of the foregoing remarks apply to silver as well as to gold; but it may be well to say a little here concerning the source whence silver is obtained.

Silver is found both in the metallic state, and in combination with other substances in ores, especially in ores of other metals. The silver ores properly so called, such as those of Mexico and Chili, are found in veins which traverse the hard rocks, and require a laborious process of mining for their extraction. In the silver-mining district of Chili, every encouragement is given by the government to the search for new mines. The discoverer may work a mine in any ground, by paying a small sum; and before paying this he may try, even in the garden of another man, for twenty days.

Sir Francis Head, and Mr. Darwin, have given separate but corroborative accounts of the fearful life which is led by some of the Chilian miners. The former states:—"While the *barreteros* or miners were working the lode, the *apires* were carrying the ore upon their backs; and after we had made the necessary observations, and had collected proper specimens, we ascended, with several of these apires above and below us. The fatigue of climbing up the notched sticks was so great, that we were almost exhausted; while the men behind us (with a long stick in one hand, in the cloven end of which there was a candle) were urging us not to stop them. The leading apire whistled whenever he came to certain spots, and then the whole party rested for a few seconds. It was really very interesting, in looking above and below, to see these poor creatures, each lighted by his candle, and climbing up the notched stick with such a load upon his back, though I occasionally was a little afraid lest one of those above me might tumble, in which case we should have all preceded him in his fall. We were quite exhausted when we came to the mouth of the mine; one of my party almost fainted, and as the sun had long ago set, the air was so bleak and freezing, we were so heated, and the scene was so cheerless, that we were glad to hurry into the hut. . . . I then sent out for one of the apires with his load. I put it on the ground, and endeavoured to rise with it, but could not, and when two or three of my party put it on my shoulders, I was barely able to walk under it. The English miner who was with me was one of the strongest men of all the Cornish party; yet he was scarcely able to walk with it, and two of our party who attempted to support it were altogether unable, and exclaimed that "it would break their backs. The load which we tried was one of specimens which I had paid the apire to bring up for me, and which weighed more than usual, but not much; and he had carried it up with me, and was above me during the whole of the ascent."

Mr. Darwin's account of the labours of these men is not less extraordinary:—"According to the general regulation, the apire is not allowed to halt for breath except the mine is six hundred feet deep. The average load is considered as rather more than two hundred pounds, and I have been assured that one of three hundred pounds (twenty-two stones and a half) by way of a trial has been brought up from the deepest mine! At the time the apires were bringing up the usual load twelve times in the day, that is, two thousand four hundred pounds from eighty yards deep; and they were employed in the intervals in breaking and picking ore. These men, excepting from accidents, are healthy, and appear cheerful. Their bodies are not very muscular. They rarely eat meat once a week, and never oftener, and then only the hard dry charqui (dried beef). Although with a knowledge that the labour is voluntary, it was nevertheless quite revolting to see the state in which they reached the mouth of the mine; their bodies bent forward, leaning with their arms on the steps, their legs bowed, the muscles quivering, the perspiration streaming from their faces over their breasts, their nostrils distended, the corners of the mouth forcibly drawn back, and the expulsion of their breath most laborious; each time they, from habit, utter an articulate cry of 'ay—ay!' which ends in a sound rising from deep in the chest, but shrill like the note of a fife. After staggering to the pile of ores, they emptied the "carpacho;" in two or three seconds recovering their breath, they wiped the sweat from their brows, and, apparently quite fresh, descended the mine again at a quick pace. This appears to me a wonderful instance of the amount of labour which habit (for it can be nothing else) will enable a man to endure."

The smelting and purifying of the silver depend, for their mode of arrangement, on the kind of impurities combined with it in the ore. It is, however, in most instances, broken and pounded, roasted to separate the sulphur and other volatile ingredients, and melted to separate the other metals from it. The two processes of amalgamation and cupellation, before spoken of, are frequently adopted.

Gold and Silver-Beating.

One of the forms in which both gold and silver are employed in manufactures is that of a leaf of extremely minute thickness. This attenuation is brought about mainly by hammering, in a very singular way. The process is nearly the same for silver as for gold; but as the former metal cannot be beaten so thin as the latter, gold will serve as an example of both.

The gold employed for this purpose (as for almost every purpose connected with manufactures) is slightly alloyed; that is, it is not quite pure. It contains about one-eightieth part of its weight of copper and silver; which is made to combine with it by melting the three in a black-lead crucible, and pouring the melted metal into an ingot-mould six or eight inches long. The ingot of alloyed gold obtained by this means is "milled," or passed between polished steel-rollers, until it is reduced to a flat thin ribbon. This ribbon is cut up into small squares, which are hammered on an anvil until each piece becomes about an inch square: in this state the gold is about 1-760th of an inch in thickness; and each small square piece weighs about six grains. A packet is made up, consisting of a hundred and fifty of these small squares, between every two of which is placed a piece of vellum about four inches square; a parchment envelope is wrapped round the packet, and it is beaten on a smooth flat stone with a heavy hammer. The packet is turned over and over, and round about in various directions, and the blows of the hammer are so given as to act equally on every part, until at length the small squares of gold are expanded to the size of four inches square.

Up to this point the gold is confined between carefully prepared pieces of vellum; but they are now removed from these, and interleaved among pieces of very delicate membrane, familiarly known as "gold-beater's skin." This skin, manufactured from the intestines of the ox, is exceedingly thin, smooth, and uniform in its texture, and is the only substance known fitted for the purpose. The pieces of gold four inches square are cut up into four pieces each; and these are interleaved among pieces of the gold-beater's skin, alternately. The whole group is then beaten, until the gold has become again quadrupled in size; they are taken out of the parcel, each one cut up into four, and these four similarly treated. This routine of processes is repeated until the gold has attained the required degree of thinness; the pieces being quartered time after time, and each quarter being beaten and expanded. The leaves, when finally prepared for use, are cut into squares measuring about three inches and a quarter each way, and are placed in groups of twenty-five into small books. Leaf-gold, as generally used, is but little more than the three-hundred-thousandth part of an inch in thickness! This may indeed be considered an extraordinary degree of thinness; yet it is far thicker than the film of gold on the surface of gold-lace, alluded to in a former paragraph.

Gold and Silver-Plate Manufacture.

This beautiful branch of art is one which calls for the exercise of great taste as well as mechanical skill. The costly display of plate which is exhibited on the sideboards of the wealthy, would lose very much of its charm were it not the result of a graceful and highly ornamental design. In past ages in Italy, the workers in gold and silver ranked their art only a little lower than that of sculpture, in respect to the patterns selected for imitation. Benvenuto Cellini, an enthusiastic artist whose name we have had occasion before to mention, exercised the art of the goldsmith during one period of his life, and threw into it the same degree of energy and genius which he displayed in other matters: he evidently regarded it rather as a *fine* art than a *mechanical* art.

The manufacture of a service of plate, such as we find at the present day, partakes of much variety in the processes, according to the costliness of the material used. These varieties are mainly three: plate made throughout of gold; plate of silver coated with a thin layer of gold; and plate of some cheap whitish-coloured metal, coated with silver—to which we may perhaps add the essentially-modern process of electro-gilding and silvering. There are, however, in all these varieties, certain mechanical processes which are pretty uniform, and are equally requisite for all.

The material called "Sheffield-plate," which has come so very largely into use during the present century, is a foundation of cheap metal coated exteriorly with silver. It was preceded, as a branch of manufacture, by a method adopted by the French, who laid thin leaves of silver on a heated metallic surface, and burnished them down upon it. The Sheffield plate is formed substantially of a metal thus prepared:—An alloy or mixture of copper and brass is cast into the form of an ingot about twenty inches long, three inches broad, and one and a half thick. One surface of this ingot is carefully cleaned, and on it is laid a thin sheet of silver, about one-fortieth the thickness of the ingot itself. The two, being tied together with wire, are touched at the junction with a little borax, and exposed to the heat of a furnace, by which the silver becomes soldered inseparably to the coarser metal. The silvered ingot is then milled in a rolling-machine, until it is reduced to the form of thin sheets; and the sheets thus made are employed in the manufacture of the various articles which come under the denomination

of "plated goods," by such processes as stamping, punching, hammering, &c.

If a piece of plate be made of solid silver instead of silvered copper, the formation of the compound ingot is not necessary; but the silver is brought by rolling to the state of a sheet, and this sheet is worked up into form by processes very similar to those adopted for the cheaper kind of plate coated only with silver. With respect to plate made of solid silver but coated with gold, the manufacture is carried on in the same way; but the gold is applied by a chemical process, either such as that adopted in button-gilding, or some other of a more delicate nature.

There is an intermediate quality of goods between the real silver-plate, and the silver which is plated on copper: it is called plate "with silver edges." When a piece of plate has an ornamental edge, and this edge is formed of the thin sheet of silvered copper, the silver soon wears away, and leaves the copper visible. To obviate this, in the better kind of plated goods, the edges are stamped out of very thin sheet silver, and the hollows of the stamped ornaments are filled up behind with a fusible white metal; after which the edges are affixed to the articles of plate. By this means, should the silver wear away, it exposes a white surface underneath instead of a coppery one.

In making a piece of plate the first process is to draw the design on paper, and make a model in wax. From this model, when properly worked up, the article is prepared by casting, by stamping, by brazing, or by all these combined, according to its nature and shape. If by casting, a lead mould is made from the model; and after many subsequent operations, the article is cast in a sand mould, in the same way as with coarser articles, but with greater care. The cast, if of silver, is prepared by further mechanical processes; but if of coarser metal, arrangements are then made for coating it with silver.

In forming articles by hammering or "brazing," the piece of metal is rested on an anvil and made to yield to the repeated blows of a hammer, by which it is wrought into form. Many varieties of shape are given to it by means of a kind of clasp called a "swage," which compresses it into a hollow on one side, and a protuberance or convexity on the other. In all those diversities of form produced by stamping, there are two dies employed, one fitted to give the pattern to one side of the metal, and the other to the other. The metal is placed down flat in or on the lower die, and the upper die is made to press it, either by falling with great force from a height, or by being worked with the lever and screw of a press.

The modern and admirable art of electro-gilding and silvering takes up the routine of operations at a point where the mechanical processes are pretty nearly brought to an end. Supposing the designing, modelling, casting, chasing, stamping, brazing, and soldering to have been performed, the article thereby produced exhibits the exact form and pattern of the piece of plate required to be made, but it has no silver or gold upon it. The metal of which it is formed is a compound of copper, nickel, and zinc; remarkable for its hardness and whiteness.

When quite prepared, the article is dipped into a tank containing liquid placed in connexion with a galvanic apparatus. It would be opening up a whole circle of science to explain the source and nature of this wonderful process; but it will suffice here to say, that when a galvanic current is made to pass through a liquid containing a metallic solution, the metal becomes separated from the other ingredients, and precipitated on any surface prepared for its reception. The liquid in the tank contains a chemical solution of silver, and into this the prepared article is immersed: in a short time the galvanic action causes the deposition of a thin layer of metallic silver from the solution upon the surface of the white metal; and by continuing the action for a greater or lesser period, this film of silver may be procured of any desired thickness. Instead of silver it may be copper, and this copper may itself be afterwards coated with silver by similar means; or it may be gold, deposited by a second process on a previous deposit of silver. In fact there are many different metals which have by degrees been brought under the dominion of this most extraordinary agent; but it is chiefly as a means of depositing a layer of silver on a foundation of some cheaper metal beneath, that it is employed in the arts.

Sometimes an article of solid silver is made wholly by this deposition, in the following way: After many modellings and castings, there is produced a perfect model in an elastic composition, and this model is dipped into a tank containing a solution of copper. Copper is made to deposit on it to a considerable thickness; and the composition being melted out, the copper forms a shell which, on being afterwards immersed in a silver solution, becomes coated with this metal to any required thickness. Lastly, by immersion in a corrosive acid, the copper is all eaten away, leaving the silver in a pure state.

Various processes of planishing or hammering, burnishing, &c., are required after the deposition, to bring the gold or silver surface to a finished state. Many of the operations above spoken of are illustrated in the wood-cuts. In Fig. 1120 are the tanks in which the galvanic deposition of the silver takes place; in Fig. 1122 is the process of "burnishing" silver plate, by means of burnishers made of hard stone; in Fig. 1123 is a peculiar process of soldering, in which the use of a powerful jet of oxy-hydrogen is rendered necessary by the great infusibility of the solder employed for the modern white metal: in Fig. 1124 is shewn one of the modes of forming the rim of a piece of plate by "brazing" or "swaging;" in Fig. 1125 are shewn the steps by which solid deposition of silver takes place; *a* being the model, *b* half of the elastic mould, *c* the copper shell, and *d* the finished article. Fig. 1127 shows the mode of "planishing," or hammering the silver plate, to give it firmness and solidity.

Quicksilver, and the less-used Metals.

Before bringing this chapter to a conclusion, a few words may be given respecting other metals not included in the preceding details.

Gold, silver, iron, steel, copper, brass, tin, and lead, are the eight metals (six pure and two compound or manufactured) which play the most important part in the arts. But there are others, such as quicksilver, platinum, nickel, zinc, bismuth, &c., which are of considerable importance. So far as they differ in their preparation for manufactures from the foregoing, a very few details will suffice.

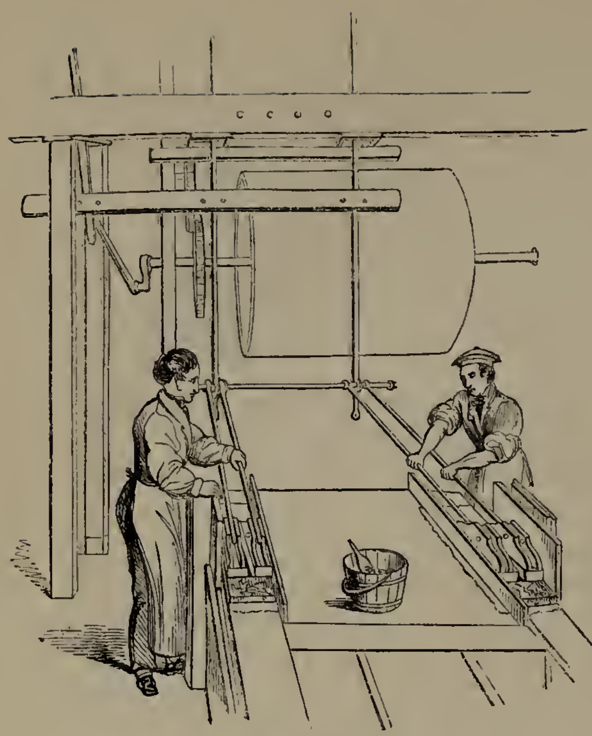
Quicksilver or mercury is remarkable as being the only metal which is fluid at common temperatures. It is sometimes found in its pure state; but for the purposes of commerce it is generally obtained from *cinnabar*, a compound of mercury and sulphur, which compound is subjected to various processes to separate the metal from the sulphur. The quicksilver mines of Idria, in the southern part of the Austrian empire, are those from which a considerable portion of the commercial supply is obtained. A traveller who described them in one of the scientific journals a few years ago, speaks thus of the position of the ore in them:—

"I had noticed from the hills a dark crowd of men in front of a large building, and those he (the guide) told me were the evening gang about commencing the descent. I appointed six o'clock in the morning, and, on waking, found him waiting for me. At the building alluded to, which is on one side of the village, and covers the entrance to the mines, we changed our dresses, and the keeper unlocking an iron gate, we found ourselves in a horizontal gallery, three or four hundred yards in length, running directly into the hill, at the foot of which the edifice is erected. . . . . Having descended by seven hundred and twenty-seven steps, reaching to a depth of one hundred and twenty-five fathoms, we arrived at the region where chiefly the cinnabar is procured. The mining operations are carried on principally in galleries, the friable nature of the ground or rock seldom admitting of larger chambers. The cinnabar is in strata of from two to six inches in thickness, and of a variety of colours, from dark to light red, the quicksilver being sometimes mixed with it, sometimes occurring in the intervening strata of earth and stone. . . . . . . Proceeding a short distance, however, we came to galleries where the cinnabar is less common, and the quicksilver is the chief object of search. It occurs here sometimes imbedded in a friable rock, sometimes in a kind of earth, in appearance and hardness resembling talcose slate, but principally in the former. Generally it is in particles too minute for the naked eye; but often, when the ore is broken, small globules present themselves, varying from a size just large enough to be seen up to that of a common pin's head; these globules are not distributed at random through the mass; but the substance in which they occur forms strata usually about an inch or two in thickness. Descending still lower, we soon came to the richest part of the mine. Here the *gangue* consists almost entirely of talcose earth mentioned above, and the globules are so large that when it is broken they fall out and roll to the bottom of the gallery. The labourers here are relieved every four hours, being unable, from the state of the atmosphere, to work longer than this at one time. In the other parts of the mine they work eight hours."

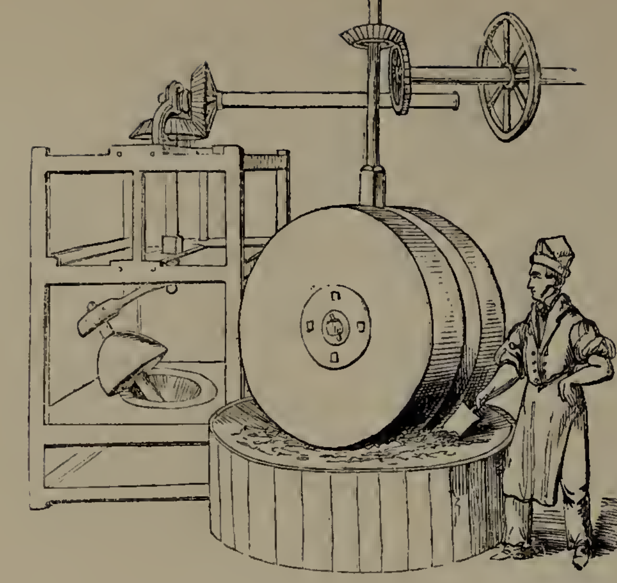
When the ore is brought to surface, it is broken into fragments, and sifted, to separate the small globules of pure mercury from it. It is then exposed to the action of a stream of water, by which the earthy impurities are gradually washed away, leaving a heavy grey powder. The powder is placed in earthen pans, many of which are heaped up in an air-tight room; fire is applied beneath the room or kiln, the heat of which drives off the mercury in the form of vapour; and this vapour, passing through apertures into adjoining cool rooms, becomes there condensed into metallic quicksilver, which adheres in small drops to the sides and ceilings of the rooms. The mercury is scraped off the walls, and filtered through a piece of canvas; after which it is stored in iron bottles for the market.

Nickel, and most of the other metals we have named, are procured by roasting and otherwise heating the ores in which they occur. Nickel is obtained chiefly from the sulphuret of that metal, by a rather elaborate train of operations; and, when thus obtained, is employed chiefly in the composition of certain alloys, such as "German silver." *Zinc* is generally obtained from a sulphuret called *blende*, or from a complex ore named calamine: these materials are picked, roasted, and smelted, by which metallic zinc is obtained in the form of bars or ingots. *Bismuth* is derived either from an oxide or from a sulphuret; and is a useful component in compound metals required to melt at a low temperature. *Antimony* is usually procured from a sulphuret of the metal, by roasting and other processes; and, when obtained, it is a useful metal in making alloys for printers' types and for music-plates. *Platina* is found nearly in a pure state; but to make it quite pure a very difficult chemical process is necessary. Its power of bearing great heat, and the action of almost any acids, renders this metal very valuable in some of the arts—one example of which we shall have to notice in the next chapter.

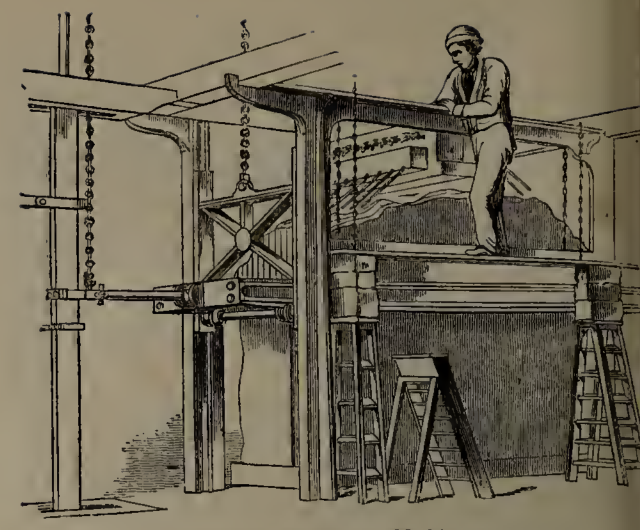
It can hardly be a subject for wonder that the metals which have thus engaged our attention should have been—in every country and in every age—more or less an object of solicitude and inventive ingenuity. They play so important a part in the daily well-being of man that they force themselves upon our notice on every side; and are, as they ever must be, among the most powerful aids to general advancement.



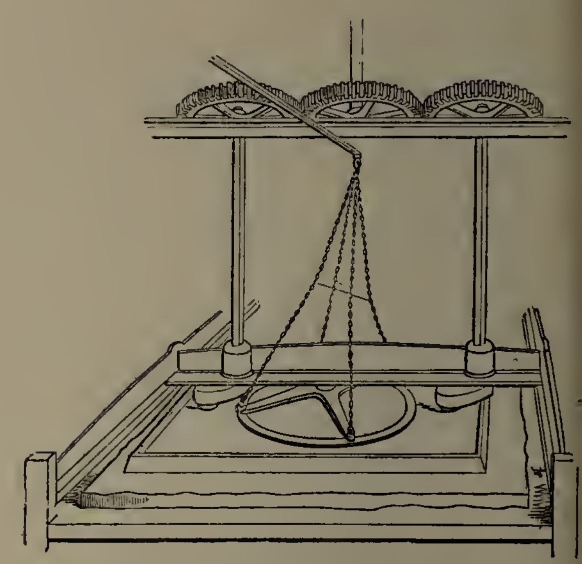
1146.—Polishing Marble.



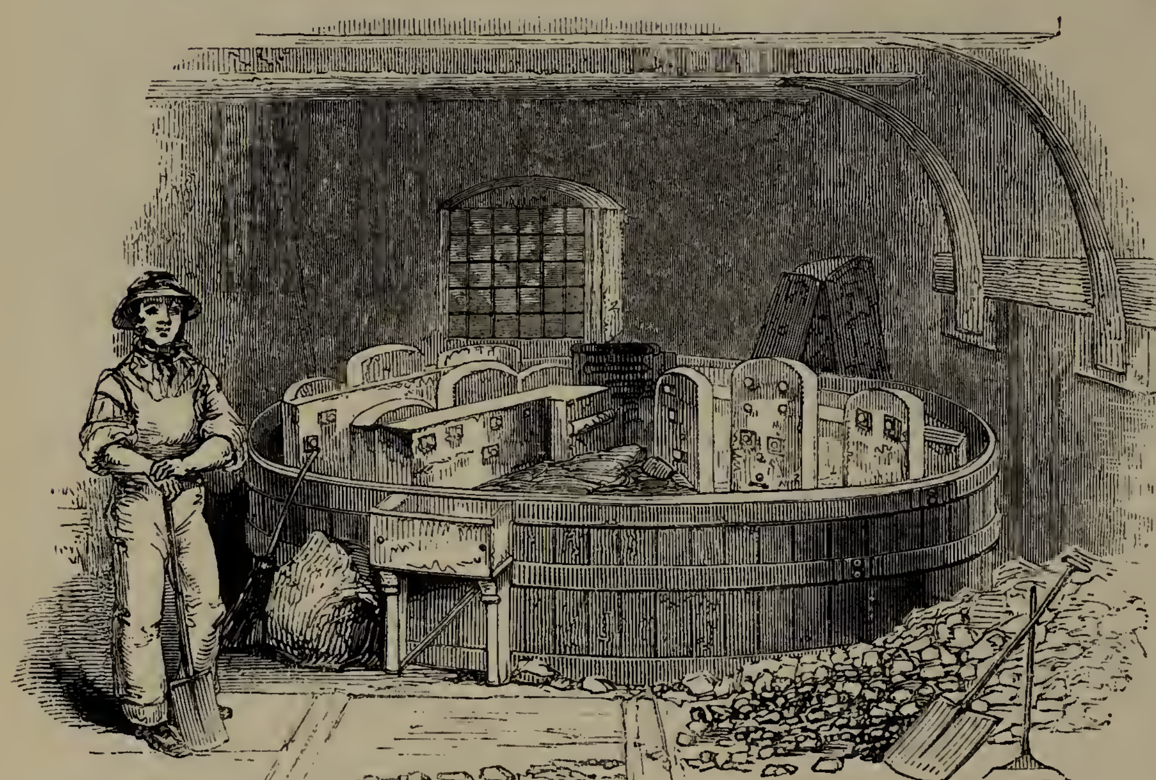
1139.—Grinding-mill and Rollers.



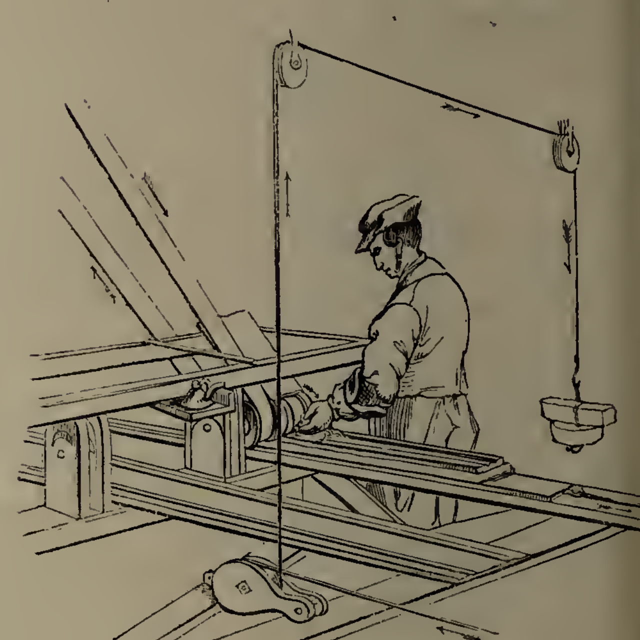
1140.—Sawing Stone by Machinery.



1141.—Polishing Marble.

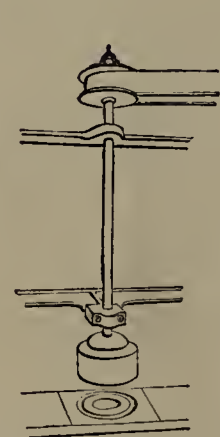


1138.—Flint-grinding.

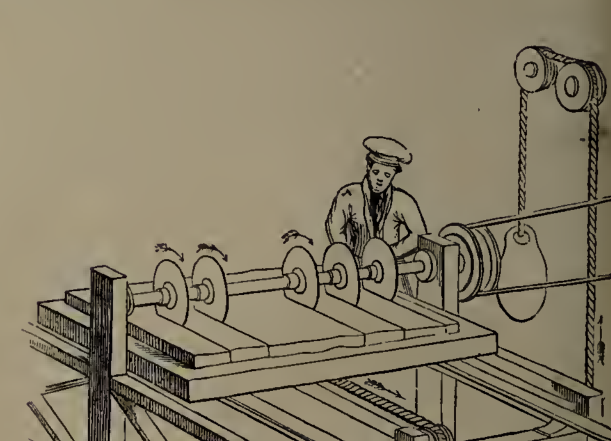


1142.—Cutting Mouldings in Marble.

1145.—Grinding the Surface of Marble.



1144.—Cutting Circles of Marble.



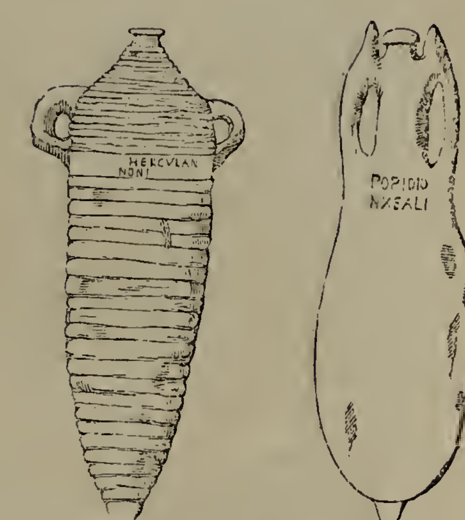
1143.—Cutting Strips of Marble.

1147.—Roman Earthen Vessels and Lamps, dug up near St. Paul's.

1148.—Ancient Greek Urns.

1149.—Greek Amphoræ, or Wine vessels.

1150.—Ancient Greek Urns.



1151.—Roman Amphoræ, or Wine vessels.

1152.—Egyptian Earthen Vessels.

1153.—Small Earthen Vessel, from Pompeii.

1154.—Earthen Jars. (From Ancient Egyptian Paintings.)

1155.—Glass Vessels, from Pompeii.

1156.—Ancient Greek Urns.

CHAPTER VIII.

THE ARTS RELATING TO MINERAL AND CHEMICAL PRODUCTS.

THE word "mineral," like many others in frequent use, is received in different acceptations at different times. It sometimes applies to the whole produce of the ground obtained by mining or digging, and then includes metals as well as earthen products; while at other times it is used in reference only to the latter. Without attempting to lay down any very precise meaning, we shall here adopt the latter rather than the former signification; and shall rapidly glance at a group of subjects which may in some respects be regarded as a sequel to the subject of the last Chapter.

MINING AND WORKING OF STONES AND GEMS.

The hard and rugged rocks which yield both our metals and our different varieties of stone, require different modes of treatment to lead to the extraction of their valuable contents. In most cases where stones are required for such purposes as building, the extraction is effected by means of open quarries, as described in p. 155, and illustrated in p. 156; but the extraction of metals or of precious stones more frequently require those subterranean excavations which belong to the department of mining. We have already spoken of mining operations in connexion with coal (pp. 47 to 54), and also in connexion with some of the metals in the last Chapter; but it may be well here to show how the miners work the hard rock to get access to the metallic veins.

The Mining System, as pursued in Cornwall.

When a vein of metal is discovered, a Company is usually formed to work it, which Company make an agreement with the owner of the ground, as to the proportion which is to come to his share. The next step is to ascertain the general direction and "dip" of the vein, in order to determine the best way of working it. Sometimes a horizontal gallery is driven into the side of a hill, until it reaches the vein; but more usually a vertical shaft is sunk to a depth sufficient to give access to it, or the shaft is sometimes made to incline a little out of the perpendicular, so as to come down upon it on the side towards which it "dips." This shaft varies from ten to thirty fathoms in depth according to circumstances; and, on reaching the vein, the miners excavate in the vein itself horizontally to the right and left. These horizontal passages or "levels" afford the means for exploring and procuring the ore at the level where they occur. The shaft is continued downwards, either vertically, or following the dip of the vein itself; until, at a certain depth below the former level, another horizontal passage is cut in the substance and along the length of the vein, thereby affording the means for further extraction. If the shaft descends perpendicularly, and does not follow the dip of the vein, "cross-cuts" are made at intervals, to give access from the shaft to the vein. So the operations continue: the shaft being dug lower and lower; the cross-cuts being made to the vein at intervals of about ten fathoms in vertical depth; and the horizontal galleries being cut in the vein itself from the cross-cuts. According to the richness and depth of the vein, so do these operations extend to a greater or lesser degree of importance.

While these operations are going on, necessity is soon found for a system of ventilation, to remove the gases and foul air, which exist so abundantly in most mines. Extra shafts and galleries, not required for the working itself, are dug from one level and one cross-cut to another, so as to give a regular passage for fresh air (forced into the mine for that purpose) throughout all the channels of the mine. If the vein is both rich in metal and deep in position, the excavations became altogether very extensive, insomuch that the ground beneath the surface-soil is almost honeycombed. For instance, where the operations have been on a large scale, if a mine were cut down vertically in the direction of the vein, it would present some such an appearance as that shown in Fig. 1128, where the strong black vertical line shows the great shaft, with the steam-engine at the top of it; the upper horizontal line is the "adit," bored from a neighbouring valley; the other horizontal lines are the working "levels" or galleries, at distances of ten fathoms apart; the short vertical lines are the "winzes," which aid in ventilating the mine; and the shaded parts represent the portion of the vein which may be supposed to have been worked or dug away. A section, taken exactly at right angles with the former, would give Fig. 1129, where the inclined vein is shown to be cut by the vertical shaft.

When the vein is sufficiently laid open by these means, the miners proceed to extract the ore. This they do either by sharp "picks" and hammers, or by blasting with gunpowder, according to the hardness and position of the vein. All the fragments, as they fall down, are shovelled or lifted into small carts, which traverse the galleries on tram-roads, until they arrive at the great vertical shaft, where they are drawn up by means of a steam-engine. When the excavations have gone to a very great distance from the shaft, the ventilation becomes very bad, and the labour of carrying all the ore to the shaft for removal is considerable. In such circumstances, one or two other shafts are sunk, at a considerable distance from the former, but still at such points as will intersect the vein at some depth or other. These subsidiary shafts are not only dug from the surface, as the first one had been, but by a series of very accurate surveyings and measurements, the exact position of the intended shaft with respect to the cross-cuts and galleries of the mine is formed, and the miners are enabled to work both upwards and downwards, as in Fig. 1130. In some of the older and larger mines these operations have been repeated so often that there are several shafts all leading down to the same vein, and the excavated passages become collectively of enormous length.

In most of the metal-mines the shafts for the extraction of the ore are rectangular, and measure about six feet by four; but those whence the water is pumped out of the mine are rather larger. Where the vein is so situated in a hill that a horizontal gallery or "adit" can be carried out from the vein to the side of the hill near a neighbouring valley, such a means is often adopted for draining the mine of the waters which gradually accumulate in it.

In some mines in the north of England, an adit has been excavated nearly four miles in length for this purpose, managed in position so as to drain several mines at once. There is another adit in Cornwall which drains a whole district; its length, together with its various ramifications, is nearly thirty miles; and it empties the waters which drain from the mines into a valley which flows into the sea. Instead of being merely one adit, there may be several, branching out according to the direction of the mine.

The operations of the miner are often disturbed by "faults," or dislocations of the vein, or by two veins intersecting each other at an angle. In Fig. 1136, for instance, two veins are shown as intersecting each other, and one of them appears to have been not only intersected, but driven out of its rectilinear position; while the strata around are also disturbed in position. There are often in such cases a number of small fissures or veins, as *j j*; but these contain mineral deposits different from those of the great veins. Such intersections and dislocations of veins as these often give rise to great trouble and expense to the miners, since they sometimes suddenly lose sight of a vein, and do not regain it till after a wide search and excavation around the spot.

When the ores, instead of occurring among the harder rocks, as in Devon and Cornwall, are found among stratified rocks of a later geological era, the mining operations differ in some of their features. Wherever such is the case, and there are many different strata superposed one on another, the mineral ore is generally found only in one or in a very few of these strata; the others being comparatively poor. In Fig. 1131, for instance, the metallic vein is found only in one of the strata, and the mining operations are planned with a view to obtain the readiest possible access to this stratum, without regard to the others. In most instances of this kind the works are conducted rather by horizontal adits than by vertical shafts.

There are several modes adopted of raising the water which occasionally floods most mines, and also the ore which is excavated. One of these is the "horse-whim," "whimsey," or "gin," for it is called by all these names. There is a kind of drum, to which a horse is attached, and by the movement of the horse in a circular path the drum rotates, and a rope coiled round it pulls the buckets up the shaft (Fig. 1132). When the power required is too great to be furnished by such means, a water-wheel is provided (Fig. 1133). Reservoirs are often formed artificially in the upper valleys, to furnish a stream for moving the water-wheel; wheels so employed vary from ten feet to fifty feet in diameter, and some of them have a power equal to that of a hundred horses. There is, besides the water-wheel, a sort of capstan to be worked by hand. These water-wheels are more extensively used on the Continent than in our own country; for in England the steam-engine, from the time of its first adoption, has been a favourite source of power in the mining districts; and many of the most important improvements in that engine have been due to the Cornish engineers. The steam-engine of a mine is usually erected close to the shaft up which the water is pumped (Fig. 1134), one end of the engine-beam being attached to the pump-rod. The water is raised by the engine, but the ore is raised, and the miners lowered and raised, by means of the capstan; unless there is a separate shaft for these latter.

An important part of the mining operations is that which involves some kinds of carpentry. When the excavations have proceeded to a considerable length and depth, the ground is so hollowed out that it would be liable to sink in and bury all beneath it, were it not supported by beams, boarding, and other timbers. The horizontal galleries or levels, for instance, are supported in the way shown in Fig. 1135, by pieces of wood placed at intervals up the sides and across the top. These constructions, especially in deep mines, form a most serious item in the costliness of the preparatory arrangements; so that a large capital has to be expended before any return can be obtained from it.

Diamond-Mines of India and Brazil.

There are some kinds of gems which are met with very much in the same manner as gold; that is, by being washed out from the rocks or beds where they were originally deposited. Among this class are *diamonds*. A district enriched in this way is that of Sumbhulpore, in India. The inhabitants of this district dig in the beds of torrents, or among the mud and sand brought down by the periodical rains to the river Mahanadi, in search of diamonds. This accumulation forms an extensive mud-bank, for a distance of more than a hundred miles on the shore of the river; and throughout the whole of this space the diamond-seekers ply their unwholesome avocation, from the ending of the rainy season to the commencement of the next. There are two particular tribes of men employed in this way, in number about five hundred, and all seriously affected by the insalubrity of the marshy spot where they are employed. These men, accompanied by their wives and children, carefully examine every spot where a deposition of alluvial matter has taken place; and their labours are said to be rendered unnecessarily severe by the prevalence of a belief among them that diamonds grow like plants, and that if a small fragment had been left from a former search, it will have grown up into a larger one.

The way in which they effect their search is as follows. By means of a sharp pickaxe the men dig into the soil, and deposit on the bank of the river the mud and sand which they thus loosen. Here the women and children look over it. They take a plank, five feet in length by two in width, hollowed out in the middle, and furnished with a rim on each side three inches in height: they place this plank in a position inclined just enough to allow water to run off; heap upon it the mud and sand dug from the river, and continue from time to time to pour water upon it. As soon as the water runs off perfectly clear they look carefully over the hard stony matter which is left on the plank, and pick out all the loose pebbles and larger pieces of gravel; these they throw away, and the remaining mass, consisting of smaller grains, they remove to another plank, of the same form as the first but smaller, and spread it carefully over the surface. They then examine every particle separately, one grain at a time, throwing away all that is merely stone or gravel, and laying aside every particle of gold or diamond. They manage to place the board at such an angle that

the sun shall shine full upon the small particles, so as to render them the better visible.

The diamonds so obtained belong to the British Government, under certain regulations with the finders; but smuggling is supposed to have been pretty extensive in the district.

Brazil is another country producing these precious gems. They are sought for by negroes, under the employ and control of the government. The diamonds exist among the sand in the bed of a river; and the first operation consists in digging up this sand and conveying it to a spot convenient for washing. This collection goes on during the dry season, and the negroes are employed during the rainy season in washing the sand so collected. The sand is placed in large heaps, and streams of water are brought to the spot by aqueducts and troughs. Mr. Mawe describes the arrangements for washing thus:—"A shed is erected in the form of a parallelogram, twenty-five or thirty yards long, and about fifteen wide, consisting of upright posts, which support a roof thatched with long grass. Down the middle of the area of this shed a current of water is conveyed through a canal covered with planks, on which the *cascalho* (sand) is laid two or three feet thick. On the other side of the area is a flooring of planks, from four to five yards long, embedded in clay, extending the whole length of the shed, and having a slope from the canal of three or four inches to a yard. This flooring is divided into about twenty compartments or troughs, each about three feet wide, by means of planks placed on their edges. The upper ends of all these troughs (here called "canoes") here communicate with the canal, and are so formed that water is admitted into them between the planks that are about an inch separate. Through this opening the current falls about six inches into the trough, and may be directed to any part of it, or stopped at pleasure, by means of a small quantity of clay. Along the lower ends of the troughs a small channel is dug to carry off the water."

Such being the arrangements, when the earthy particles are washed away, the gravelly particles remain. This gravel is carefully examined; and when a negro finds a diamond among it, he rises up and claps his hands; and one of the overseers receives it from him. In the evening, all the diamonds that have been found during the day are given up to an inferior officer, who weighs and registers them. A negro who may be so fortunate as to find a diamond weighing seventeen carats and a half receives his freedom; while premiums are given to the discoverers of smaller stones. The diamonds are deposited in chests, several multiple keys of which are kept by different officials. They are all despatched once a year to Rio Janeiro, the capital of Brazil: this embassy or convoy, being one of great commercial importance, is managed with much care; the officers and soldiers are selected according to their trustworthiness; the bags of jewels are carried by mules; and the cavalcade forms a well-armed party (Fig. 1137).

Turquoise Mines of Persia.

Another remarkable gem, in respect to its nature and source, is the *turquoise*. This beautiful greenish-blue stone was at one time supposed to be a sort of fossil bone tinged with copper; but it is now known to be a proper mineral substance, of argillaceous or clayey origin, and tinged with oxide of copper.

The chief supply of turquoises is obtained from the province of Khorasan, in Persia, in a mountainous district about forty miles westward of Nishapore. Mr. Baillie Frazer states that there are six mines in which the stone occurs. In the first there is a bed of light grey porphyritic earth, which is turned over and over by the miners; and bits of the turquoise are found attached to fragments of the rock. In the second, the rock consists of porphyritic earth deeply tinged with iron, and having little veins of the blue turquoise matter pervading it in every direction, but principally between the laminæ of the rock. In the third, the operations were suspended at the time of Mr. Frazer's visit ('Journey to Khorasan'). In the fourth, the turquoise matter is disseminated in small veins through a solid dark brown rock. In the fifth, the contents of the mine have been nearly exhausted, and it is no longer worth working. In the sixth, which is the most valuable of all, the turquoise matter pervades both a porphyritic rock and a yellow ochreous clay; and it occurs in the forms of tolerably symmetrical nodules, of narrow veins pervading the rock, and of irregular masses.

The mines are worked in a very slovenly manner. There are no shafts or chambers, or galleries formed; but the miners dig just where they think the rock is richest, and leave the rubbish where it falls, blocking up and encumbering the passages. Sometimes they chip away large pieces of the rock by means of picks and hammers, extract the turquoise in the best way they can, and leave the rest of the rock unmoved. No system is laid down by which the mining is to be conducted; but each one selects a spot where he pleases and works it in what way he pleases. As soon as an excavation is filled up with rubbish, the miners go to another; and if a mine happens to be inundated with water, they at once abandon it, without making any attempts at drainage. The mines belong to the Crown; but in consequence of the badness of the system followed, a much smaller revenue is derived from them than might otherwise be obtained. The mines are farmed out to the highest bidders; and these are generally the inhabitants of two neighbouring villages, who work the mines as well as farm them. The villages contain about a thousand inhabitants, of whom two hundred are employed at the mines. One hundred of the villagers take the whole of the mines at the price agreed on, and work together in parties of five or ten, who divide the produce of their labour either collectively or by these separate parties, each contributing his share of the rent of the mines. The produce is sold to merchants who resort to the spot for that purpose; or else is sent for sale to Mushed, the chief city of the province.

The turquoise stones, as sold by the miners to the merchants, are in three varieties of form. The first of these is of single stones, separated from the adherent rock, and ground so far as to expose the size, shape, and colour; and the buyer and seller make their bargain according to the excellence of the stone. The second kind includes those which are not wholly separated from impurities; and as the merchant does not know the real quality of each individual piece, he bids a price for the whole lot, good and bad, certain and doubtful, together. The third kind consists of masses of rock with the turquoises imbedded in them, and these are sold by weight, according to the supposed or ascertained richness of the ore.

Cutting and Grinding of Precious Stones.

Most of the costly minerals which come under the denomination of "precious stones" are found in some such way as the diamonds and turquoises just spoken of; and when procured their transformation to an ornamental appearance requires peculiar tools, owing to the excessive hardness of most of them.

In the case of the Persian turquoises, most of them pass into the hands of lapidaries at Mushed, who are employed by the merchants to bring the gems into proper form. These lapidaries use a wheel covered with gum-lac and sand, mixed while the first is in a state of fusion; this wheel is from a quarter to a third of an inch in thickness, and is turned rapidly by a bow and string fitted to its axle. The workman holds the gem in one hand, turns the wheel with the other, and grinds the gem by applying it to the rough surface of the wheel. When the stone is sufficiently worn away, it is polished by being applied to the surface of a smoother wheel than the first, but managed in a similar way. In most cases these gems are worked up into the form of rings.

The cutting and shaping of diamonds are more difficult processes than in respect to any other stones, on account of the excessive hardness of this gem. Nothing but a diamond can cut a diamond; and it is curious to see how this feature is acted on in practice. For most purposes of ornament, the diamond is brought into one or other of four forms, technically designated the "brilliant," the "rose," the "table," and the "lasque diamond;" differing principally in the thickness as compared with the diameter, and in the number of "facets" or little flat surfaces produced by the lapidary. Although the diamond cannot be cut or ground except by another diamond, it may be *split* by different means. To effect this the diamond is imbedded while warm into a small lump of resinous cement, just to such a depth as to leave uncovered that part which is to be separated. Another diamond, having a sharp edge, is fixed in another ball of cement; and with this edge a slight notch is made in the stone to be split. Into the notch thus made is placed the edge of a blunt razor-blade, and a smart blow with a hammer splits off the portion of diamond which projects beyond the surface of the cement. It is the suddenness of the blow, acting on a part of the gem which has been already slightly cut by another diamond, that severs the fragment.

The grinding and polishing of the cleft diamond are slow and tedious processes. The gem is embedded in a ball of cement fixed to the end of a stick in such a manner as to expose the part of the surface which is to be worked. Another diamond, which is also about to be ground (for two are made to grind each other at the same time) is similarly embedded in cement at the end of another stick; and the two are then made to act against each other. The diamond-worker has before him on a bench a very small mahogany box, on the top edge of which is a rim of steel, with two steel pins rising perpendicularly; the sticks are held forcibly against these pins, and the two diamonds are rubbed together with the heaviest pressure which the workman can get to bear upon them. All the fragments which are rubbed off are in the state of a very fine powder; and this, called "diamond-powder," falls on a perforated steel plate in the box, and thence through the perforations into a receptacle beneath. All this process is required for producing one "facet" or small flat surface only on each diamond; and when this is completed, the diamond requires to be removed from the ball of cement, and re-adjusted in a new position preparatory to the grinding of a new facet.

When a proper form has been given to the diamond by these means, the process of polishing succeeds. For this process the diamond is fixed and held in a manner rather different from before. Instead of being embedded in cement, it is embedded in pewter or fusible metal to such a depth as to leave no part exposed but the facet which is to be polished. The pewter is contained in a little hemispherical cup, which serves to give it solidity. It is placed, with the diamond downwards, on the surface with which the gem is to be polished. A circular cast-iron plate, called a *skive*, about a foot in diameter, is first turned flat and true in a lathe, then slightly roughened with gritstone, and then so fixed to a lathe as to be made to rotate rapidly in a horizontal direction. A little diamond-powder, mixed with olive-oil, is spread on the upper surface of the skive, and the pewter is laid on so as to place the diamond in contact with this surface, a weight more or less heavy being pressed on it. The skive being then made to rotate, the continued friction between the diamond and the layer of diamond-powder polishes the facet.

The diamond is not only indispensable in thus grinding and polishing other specimens of its own kind, but it is also extensively employed in grinding and polishing other gems: indeed, the lapidary would be almost brought to a stand in his proceedings were he deprived of "diamond-powder" as a working material. In the cutting and polishing of gems generally, the lapidary is provided with a small mill, the arrangement of which is such as to enable him to keep a flat plate rotating in a horizontal direction. The upper surface of the mill-plate is that on which the grinding of the gem is conducted; and the plate is therefore formed of material adapted to the kind of gem. The diamond requires a mill-plate of steel, coated on the upper surface with diamond-powder moistened with olive-oil. Gems of the next degree of hardness, such as the sapphire and ruby, require a mill-plate of copper, coated as above. The next softer varieties of gems, including the beryl, topaz, amethyst, garnet, and hyacinth, require a leaden mill-plate. The softest kinds, such as quartz, opal, and artificial gems, require a mill-plate of wood. These distinctions arise from the circumstance that the mill-plate for grinding each gem must be proportional in hardness to, but not so hard as, the gem to be ground.

The gem to be ground is cemented to one end of a small rod; and the lapidary having the means of giving a very rapid rotatory motion to the mill-plate, he applies the gem to it, and grinds away the substance of the gem according to the kind of effect required to be produced. For grinding diamonds, sapphires, and rubies, the mill-plate is touched with a little diamond-powder and oil, to give the requisite abrading power; for emeralds, beryls, topazes, garnets, hyacinths, and all the softer gems, emery and water are applied to the plate. The grinding wears away the surface of the gem in various parts; but the new surface thus produced is dull or without lustre; and to impart this lustre the gem is polished on softer mill-plates with Tripoli and water.

Seal-Engraving: Artificial Gems.

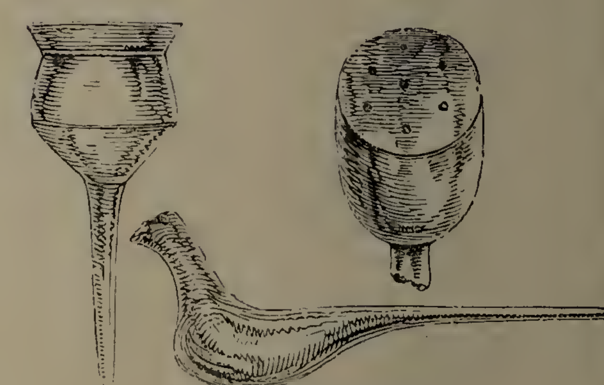
The engraving of seals is an operation nearly allied to that of cutting and polishing gems, since the material in both cases is very hard, and requires the action of a rotating edge to cut it. Generally speaking, it is the softer kinds of gems, such as cornelian, chalcedony, rock-crystal, amethyst, and onyx, which are best calculated for engraving. The diamond, the sapphire, and the ruby are too hard to be fitted for this operation. The beryl, the topaz, and the emerald are sometimes engraved. Among the ancient Egyptians, jasper, turquoise, granite, and porphyry were engraved upon. Whatever be the kind of gem employed, it is first ground to the proper form by the lapidary, and then engraved by the aid of a small and delicately-constructed lathe. A small steel cylinder or bar is made to rotate very rapidly on a horizontal axis, and on one end of this cylinder is fixed a very minute disc or wheel, which forms the cutter or engraving tool. The engraver is provided with a large variety of these wheels; some of them present a square edge, others a sharp, a globular, a hollow; the largest of them is about three-eighths of an inch in diameter, while the smallest is scarcely visible—so minute are the lines and indentations required to be made by these tools. The seal-engraver fixes the gem by cement to the end of a stick; draws on the face of the gem the outline of the device or subject, by means of a fragment of diamond; moistens the edge of the little wheel or disc with diamond-powder and oil; sets the wheel in rapid rotation, and then applies the gem to it. By altering the size and shape of the wheels employed, he is enabled to produce all the minute and delicate cuttings which are observable on a seal. When the cutting or engraving is finished, the surfaces produced are dead and rough; but these are made to receive a polish by friction against other wheels, similar to the former in shape and size, but made of softer materials, such as copper, pewter, or

1157.—Fragments of Roman Pottery, dug up in London.

1158.—Egyptians carrying an Amphora, or Wine vessel.

1159.—Egyptian Earthen Vessels.

1164.—The Warwick Vase, in the grounds of Warwick Castle.



1160.—Glass Vessels, from Pompeii.

1161.—Earthen Jars. (From an Ancient Egyptian Painting.)

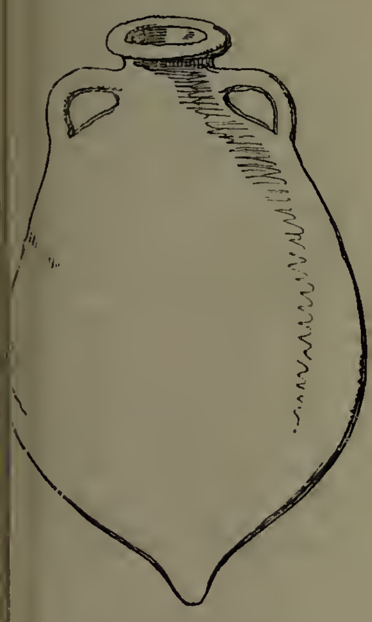
1163.—Fragments of Roman Pottery, dug up in London.

1162.—Roman-British Earthen Vessels.

1165.— Ancient Egyptian Porcelain Vessels.

1166.—Egyptian Earthen Vessels.

1167.—Earthen Jars. (From ancient Egyptian painting.)



1168.—Earthen Amphora.

1171.—Earthen Cup, from Pompeii.

1172.—Oriental Ewer and Basin.

1169.—Glass Vessels, from Pompeii.

1173.—Terra-Cotta Vase.

1170.—Pompeian Drinking-vessel.

1178.—Portland or Barberini Vase, in the British Museum.

1174.—Greek Amphoræ, Earthen Vessels.

1175.—Ancient Egyptian Earthen Vessels.

1176.—Earthen Vases.

1177.—Clay Liquor-baskets, from Pompeii.

hard wood, moistened at the surface with Tripoli-powder and water.

Allusion has been made above to "artificial gems." These are a kind of coloured glass, so manufactured as to cheat the unpractised eye into a belief that they are real gems. This art seems to have been much practised in early times. In a collection of antiquities at Rome there are shown two artificial specimens, a chrysolite and an emerald, so admirably executed that they are not only coloured and transparent to the proper degree, but show no blemish either externally or internally. The Emperor Adrian is said to have received as a present from an Egyptian priest several glass cups which sparkled with colours of every kind; and which, as costly wares, he ordered to be used only on grand occasions. In all such examples of imitative art the substance employed is a sort of glass, which has received colour by the admixture of various metallic oxides. The basis of all artificial gems is "paste" or "strass," a colourless glass with which diamonds are imitated. This paste is made, in a very careful manner, of silica or flint, potash, borax, and oxide of lead—ingredients pretty nearly the same as those employed for flint-glass. The material thus produced is either placed in the hands of the lapidary, to be worked up into a form that shall imitate that of the diamond; or it is mixed with metallic oxides or chemical agents to produce imitations of other gems—for ruby, manganese; for emerald, copper, iron, and chromium: for sapphire, cobalt; for amethyst, manganese and cobalt; for beryl, antimony and iron; for garnet, antimony and manganese—and so on: each particular artist having his own favourite recipe for each particular imitative gem.

Marble and Stone Cutting and Polishing.

If the cutting and polishing of a gem are more delicate and costly operations than the cutting and polish ing of a block of marble, the latter are, perhaps, commercially more important; inasmuch as they include the stone-working processes so largely involved in the construction of buildings. In a former chapter (p. 154) marble and stone are spoken of in respect to the quarrying operations; and here they may fittingly be considered in relation to the modes of working up the rude blocks into elegant forms.

However varied may be the qualities of the several kinds of stone adopted for building purposes, the manner of cutting them is pretty uniform. The blocks are in the first place hewn to a tolerably square form at or near the quarry, and are in that state conveyed to the statuary's or mason's premises. The textures of the different kinds vary a good deal, but the colours vary still more. Marble is a fine kind of compact limestone, having a very close grain, and susceptible of receiving a high polish. The name itself means simply something that "shines" or "glitters," and at one time included basalt, alabaster, serpentine, porphyry, and other kinds of stone, as well as marble, such as we now understand the term; but in modern days the acceptation is much more limited. Some of the varieties, such as the Carrara marble, are purely and beautifully white. Some are as beautifully black; such as those obtained from Derbyshire and from a quarry near Galway; there is in the British Museum a table, presented by the Duke of Rutland, of which the framework, legs, and bottom plinth are formed of such marble as is here spoken of. The larger varieties of marble, however, are more or less veined with different colours: sometimes by the admixture of small particles of hornblende, but more frequently by receiving a stain from one or other of the oxides of iron.

In most cases a block of stone or of marble is brought to the state of a slab or thin piece, preparatory to other operations. The white marble for statuary, and the large building-blocks for masonry, are exceptions; but these require sawing just the same as the others. This sawing is rather a curious process; for the cutting instrument is not a saw at all: it is a knife, and a knife which must neither be sharp nor made of hard steel. The stone-saw is a strip of soft sheet-iron, with a blunt straight smooth edge: it is fixed into a frame to keep it in shape, and is drawn to and fro over the surface of the stone to be cut. A little sand moistened with water is allowed to flow into the crevice made by the saw; and the small particles of this sand act in some degree the part of saw-teeth; the blade of iron works them to and fro, and they cut the stone. In most cases stone is cut by a man who works the saw in a very inefficient manner, pulling and pushing it across the stone in a way which entails a considerable waste of muscular power. In some establishments, however, and especially for the cutting of marble, a machine is employed such as that sketched in Fig. 1140. This machine consists of a frame-work, containing several stone-saws, which are placed side by side, at distances apart equal to the intended thickness of the slabs to be cut. The block of marble or stone is supported on the ground or on a platform, just beneath the group of saws; and above the saws is a little apparatus for furnishing a constant stream of sand and water. A steam-engine gives motion to the frame containing the saws; and as this moves to and fro, the saws cut down by degrees through the marble, the cuts or fissures made being equal in number to the number of saws. If the block is to be cut into one thick piece, there would perhaps be only one saw in the frame; if it be cut into slabs an inch in thickness, there may be a dozen saws ranged side by side; or there may be any intermediate number, according to the circumstances of the case.

Besides the cutting of marble into slabs, there are many other modes of severing it into smaller pieces, or of cutting pieces from it. For instance, a slab may be cut up into a number of parallel strips, by employing circular saws such as those sketched in Fig. 1143: the slab is placed firmly on a stand or support; and the saws are so fixed, parallel one to another, as to rotate rapidly on a horizontal axis; and by adjusting the height of this axis above the marble, the slab is speedily cut up into strips whose width equals the intervals between the saws. Another mode is that of cutting small circular pieces of marble (Fig. 1144). Here the cutting instrument is brought to the shape of a cylinder, whose lower edge forms a circular cutter; the piece of marble is laid down flat on a bench, and the cutter being lowered down upon it, is made to revolve with great rapidity, by which the cutting is speedily effected. Small pieces are frequently cut by hand, the blade of iron being fixed into a handle which is grasped by the workman. Sometimes curved pieces are produced by fixing a rod to a hinge or fulcrum at one end, and attaching to the other end a bent piece of iron as a cutter: in such case the length of the rod determines the curvature of the piece. Large circular pieces are occasionally cut by fixing four arcs of circles to a circular wooden frame, equidistant from its centre, and effecting the cutting by means of these. By a judicious adaptation of circular cutters, hollow pillars of marble or stone are sometimes made, the external diameter being cut by one circle, and the internal by another.

When a slab or narrow strip of marble is to receive the form of a moulding or beading, or other architectural ornament, it is effected by grinding away the surface by means of iron tools; these, being harder than the stone, grind away some of the latter; and the shape of the grinding tool is so determined as to give the proper form to the moulding produced. In Fig. 1142 is shown an apparatus in which the grinding is effected by machinery. A small horizontal axle or axis is made to revolve rapidly, and on it is placed a ring of iron, whose edge is the countertype of the form of the moulding. The marble is placed on a bench just beneath the grinding tool, and in contact with it; a man supplies the two with sand and water, and the tool, by its rapid revolution, grinds away the surface of the marble; the latter being made to travel onward slowly as fast as the grinding is effected. Cast-iron, too, is used as the grinding material for removing the marks of the saw previous to polishing. Various modes of effecting this are adopted; but two will sufficiently exemplify them. In Fig. 1141 (which by mistake is designated "polishing" instead of "grinding" marble) there is a flat bed on which the slab of marble is fixed, and on this rests a large flat plate of cast-iron, which has a peculiar horizontal circular movement given to it by wheel-work; sand and water are allowed to fall through small holes in the plate, so as to assist the process of grinding, which is continued until all the saw-marks and other irregularities are removed from the surface of the marble. Smaller pieces are sometimes ground by holding them down upon the surface of a circular plate of iron (Fig. 1145) while the latter is revolving rapidly.

The polishing of marble differs from the grinding in the sort of tool employed rather than in the mode of proceeding. In the one case as in the other, the result is produced by the friction of one surface against another. The polishing surface is usually a peculiar kind of coarse felt, fixed to the bottom of a block of wood or lead: if small, it is worked over the marble by hand; but if large, it is attached to some such machine as that shown in Fig. 1146, where two polishers, attached to one moving beam or frame, are made to work to and fro simultaneously.

Turning and carving are also among the mechanical operations to which marble is subjected, and are effected pretty much in the same manner as when wood is the material operated on; but with a difference in the kind of tools employed.

Scagliola and Artificial Stone.

It might seem curious, at first thought, that any attempts should be made to produce stone or a semblance of stone artificially; since the original material is tolerably abundant, and imitation seems difficult. But for some purposes an imitative marble is cheaper than the real; and for other purposes an imitative stone is more workable and convenient for use than real stone; and these sufficiently explain the motives for the attempts.

Scagliola is a manufactured imitation of marble, and has obtained its name from the Italian word for a "scale" or "shell;" since it is a kind of incrustation of plaster on a framework of wood or other material. It was in use in Italy more than two centuries ago, and was much employed for columns and pilasters. The earliest application of it in England is said to have been in the Pantheon in Oxford Street, as originally built by Wyatt in the latter half of the last century; and it has since come into very extensive use, on account of the excellence attained in its manufacture, and the comparative cheapness at which it can be procured. It is made from very fine gypsum, which is broken into small pieces, calcined in a furnace or kiln, ground to powder, and sifted; the prepared lime is then mixed with Flanders glue, isinglass, and colouring matter according to the tint required to be given. As the material is generally used to imitate marble of variegated colours, it is necessary to mix up as many different portions of coloured material as there are colours. This mortar does not form the substance of the article to be made, but is applied as a coating to some groundwork prepared for its reception. In the case of scagliola pillars or columns, for example, the pillar is in the first place formed of brick or wood, or some other material, and then coated with a rough layer of lime and hair to give adhesion to the subsequent cement. The scagliola cement is laid on piecemeal, by means of trowels and other tools: the workman imitating the veins and streaks and spots of marble according to his ability; laying in first one colour and then another, and disposing each colour according to the part which it is to play in the general configuration of the marble. When sufficient of the fine-coloured cement has been thus applied, and allowed to dry, the surface is rubbed smooth with pumice-stone, washed clean with a sponge and water, polished a first time with a piece of fine linen touched with finely pounded tripoli and charcoal, then with a piece of felt dipped in tripoli and oil, and lastly with felt dipped in oil alone.

The manufacture of this kind of imitative marble has attained a stage of great excellence, especially in our own country, where it is now more admired than in the country where it originated. A writer in the 'Penny Cyclopædia' remarks that it "has now almost superseded the use of coloured marble for columns and other interior decorations, and has been extensively employed in Buckingham Palace and many of the Club-houses in London. It is far less costly than any kind of variegated marble, though too expensive to be brought into ordinary use on every occasion; and it answers the purpose of the real material not only as regards appearance and effect, but durability also, since it will last quite as long as any other part of the interior of a building. There is besides one great advantage attending it, that columns incrusted with scagliola are generally of wood and hollow, or else filled with a plaster core, and consequently do not require that support on the floor beneath which would be necessary if solid marble shafts were employed; and if required to support a bearing above them, the columns may be made of brick or ordinary stone, and afterwards coated with scagliola. Nor is the use of this composition confined to columns and pilasters only; for it may be and indeed is applied to other ornamental purposes, for table-slabs, pedestal-stands, dados of rooms, borders of floors, &c. . . . . By means of scagliola, not only may the costliest and rarest stones, porphyry, verde antico, giallo antico, &c. be successfully imitated, but any combination of colours may be produced; for instance, purple or emerald green streaked with gold, siena veined with purple, or any other splendid caprice that fancy may dictate."

Artificial stone of a commoner kind is generally required to possess great hardness, and a power of resisting moisture; while at the same time it is a very workable material in the first instance. Those varieties of limestone which contain a good deal of iron in their composition are very fitted to produce a cement which shall be very hard and durable when dry. The Romans made a good deal of use of a material called *puzzolana*, which was a concreted mass of volcanic ashes; this was mixed with other substances to form the almost-imperishable mortar which the Romans employed in their buildings. Three parts of puzzolana mixed with one of lime formed one of their kinds of cement. Smeaton employed a similar kind in the Eddystone Lighthouse. Chalk and sand form a hard cement; and so do a mixture of lias-lime, river sand, puzzolana, and calcined ironstone. A cement called *cendrée* is made in the following manner:—Large pieces of lias-lime are burned in a kiln, and with the ashes of the fuel are afterwards found small fragments of the lime, in the average proportion of three parts of ashes to one of lime; of this mixture about a bushel at a time is taken, and is sprinkled with water only sufficient to slake the lime; the whole quantity, thus treated, is then put into a pit and covered with earth, where it remains for some weeks; it is then taken out, and well beaten with an iron pestle for half an hour, which brings it to the consistence of soft mortar; it is next laid in the shade for a day or two to dry, and again beaten till it becomes soft; this is repeated three or four times, till at length the mortar is only just sufficiently soft for use; being then applied to brick or stone, it forms in a few minutes a very compact mass, and acquires a stony hardness in the course of twenty-four hours.

Many other modes have been either acted on or

suggested for making a cement which shall harden to the consistence of stone, and shall be at the same time impervious to water; but nearly all of these, as in the case of the so-called "Roman cement," contain lime as the principal element.

The Mechanical Processes of Sculpture.

The mere chiselling and polishing which constitute the mechanical operations of the sculptor, are employments of so much humbler an order than the contrivance or ideal creation of a statue, that we are apt to lose thought of them while gazing on the works of a Phidias or a Flaxman. Yet they are by no means devoid of interest, for they form by far the highest department of stone-cutting; and are indeed among the links which connect the Fine Arts with the Industrial Arts.

Mr. Westmacott has described the mechanical processes of sculpture so clearly in the 'Penny Cyclopædia,' that we cannot do better than make use of his description:—"The technical or mechanical processes of sculpture are for the most part extremely simple. The sculptor, having conceived or invented his subject, usually begins by making a slight sketch of it, either drawing it on paper, or at once modelling it, in small, in clay or wax. This preliminary step enables him to judge of the arrangement, and to correct and improve the general composition of his figure or group. He next proceeds to build up his statue of the desired size. The first thing necessary is to construct a sort of *nucleus*, or skeleton, by which the clay may be supported. This is made of wood or iron, according to the strength required, and the limbs are usually made moveable, by attaching the skeleton parts to the main support, or trunk, by wire joints. The figure is then built up in clay; and whether it is ultimately to be draped or not, it should always be modelled naked, in order that the true forms may be easily distinguished, and the drapery made to fall naturally. In modelling in *relief*, a plane, or ground as it is called, is prepared, upon which the sculptor carefully draws his design. The clay is then laid and pressed upon this, the outline of the figures being bounded by the lines of the drawing. The projection or fullness of the forms must of course depend upon the fancy of the artist, or the purpose or situation for which the work may be intended. The same rule with respect to modelling the figures naked should be observed here as in figures or groups in the 'round.' To preserve the models from shrinking and cracking, it is necessary to sprinkle the clay occasionally with water; and on leaving them, to cover them over with damp cloths.

"The next process is 'casting.' The model being completed, a mixture is made of plaster of Paris and water, which is thrown over the whole. When this is 'set,' or hardened, the clay within it is picked out, and there remains an exact mould of the model. This is washed, and the interior is brushed over with any greasy substance, usually a composition of oil and soap, to prevent the fresh plaster, with which it is next to be filled, from adhering too firmly to it. After the mould is thoroughly filled in all its parts with this plaster, mixed to about the consistency of cream, the latter is left to set. The mould is then 'knocked off' with chisels, and a 'cast' of the model is produced entire. If it is intended to execute the work in bronze, the same general principle is observed in the moulding; but there are particular processes to be attended to, in order to enable the mould to bear the weight of the metal, and to ensure the soundness of the 'cast.'

"In copying a model in marble, the first step is to prepare two stones of the same size, or at least with an exactly corresponding graduated scale marked on the front of each, on which the block of marble and the model are respectively to be placed. The fronts of the two scales are so constructed or fitted up, that a 'pointing' instrument can be applied to them. This instrument is usually composed of a pole or standard, to which a long brass or steel 'needle,'—capable of being extended and withdrawn, loosened or fixed, and moved in every direction by means of ball-and-socket joints,—is attached. This is made to touch a particular part of the model. The whole instrument is then removed to the scale-stone on which the rough block is placed, and the marble is cut away till the needle reaches as far into the block as it had been fixed at upon the model. A pencil-mark is then made upon the two corresponding parts of the model and block, and thus what is technically called 'a point' is taken. This process is repeated till the numerous points at fixed depths, corresponding throughout with the surface of the model, are attained, and a rough copy of the sculptor's original work is thus mechanically made. These instruments for pointing marble statues are not always constructed in precisely the same manner. The practice of different sculptors has suggested various changes in detail, by which either the movement of the whole machine from one scale-stone to the other is facilitated, or a greater rapidity and security in taking points is attained; but the principle on which they act seems to be exactly similar in all. The statue being rudely blocked out or pointed, the marble is in this state put into the hands of a superior workman called a carver, who copies the minuter portions of the work, by means of chisels of various sizes, rasps, and files; the pencil-marks or points showing him the limits beyond which he is not to penetrate into the marble. When the carver has carried the work as far as the sculptor desires, he proceeds himself to give it the finishing strokes, by retouching and improving the details of form and expression, by producing varieties of texture and surface, and by giving that general quality or appearance to the whole which constitutes what is termed harmony of effect."

Alabaster and Petrified Ornaments.

There are occasionally very beautiful ornaments made of a kind of stone which results more or less from chemical precipitation, in which lime is the chief ingredient. The term "alabaster" is sometimes applied to such petrifactions, and sometimes to a species of limestone or marble quarried from rocks.

Alabaster, properly so called, is a variety of gypsum or sulphate of lime, occurring in one of two forms, but both of which present a semi-transparent texture, and a softness of substance which enables them to be easily chiselled into ornamental forms. Some quarries of alabaster yield blocks large enough to be sculptured into statues; others give specimens so transparent as to serve as a substitute for glass in windows, when severed into thin plates; indeed there is said to be a church at Florence, in which each window consists of one single slab of white alabaster, fifteen feet high. The ancients were accustomed on some occasions to throw a subdued light into their temples by allowing the rays of the sun to pass through thin plates of alabaster.

Some pieces of alabaster are as hard as marble, but those which are generally sculptured for ornament are much softer, and yield very readily to the cutting tools employed. The process of sculpturing is a miniature representative of the higher kinds of sculpture. The alabaster is in the first place cut into blocks with steel saws; then fashioned by chisels and knives; then smoothed with rasps and files; and lastly, polished with a mixture of chalk, soap, and milk, applied on the surface of a bit of flannel.—This branch of art is carried on to a considerable extent in Italy.

The alabaster which is produced by petrifaction or deposition requires a different series of processes. Many warm springs contain an abundance of carbonate and sulphate of lime; and when the water gushes out to the light of day, the carbonic acid escapes, and leaves the sulphate of lime or alabaster to deposit itself in and around the spot where the spring flows. The white substance is therefore formed naturally; but ingenuity has contrived a mode of producing ornaments in this material while the material itself is actually being formed. At one spring of this kind in Tuscany, Dr. Di Vegni suggested some years ago the following mode of forming bas-relief and other ornaments in moulds. He collected a number of plaster models, from which he made sulphur moulds in the usual manner. The moulds were placed in a wooden vessel, round the interior of which was a row of pegs, on which the mould rested; and at the top of the vessel were placed cross-bars, which partially closed the mouth. The vessel was then placed in the midst of the hot spring, with an arrangement for preventing any disturbance of position: the water, on entering the tub, was divided into separate streams by the cross-bars, which streams dashed against the moulds, and deposited the earthy particles within the latter, until the whole surface of the mould became incrusted with alabaster. According to the angle at which the mould was placed in the vessel, and the manner in which the water was made to fall upon it, so was the deposition varied in its character; but, generally speaking, the alabaster produced was at least equal to Carrara marble, both in whiteness and hardness. A space of time varying from one month to four months, according to the required thickness of the cast, was necessary for the mould to remain in the spring; since the deposition of alabastrine matter was rather slow. At the expiration of the required time, the vessel was removed from the spring, the mould was taken out of the vessel, and the incrustation around the mould was carefully broke away; a slight blow separated the sulphur mould from the alabaster cast; and the latter, after being rubbed briskly with a hard brush, was finished.

There is in like manner a spring of alabaster at work in Peru, near a place called Guancavelica. A boiling-hot spring rises from the ground, holding an abundance of earthy particles suspended in the liquid. At a short distance from the source it becomes a little cooled, and deposits calcareous matter in such vast quantities, that not only may moulds of ornamental objects be filled with it, but large blocks of stone are actually built up, as it were, in a similar manner. The stone thus produced is hard, beautiful in texture, and susceptible of receiving a high polish—even some of the houses are constructed of it; so that the buildings may, with very little exaggeration, be said to be formed out of springs of water.

By compelling the calcareous water to filter through a coloured substance before falling in the moulds, Di Vegni succeeded in forming ornaments in coloured alabaster. The beautiful natural productions known by the name of *stalactites* are produced by the deposition of calcareous matter from springs, nearly in the same manner as alabaster.

THE PLASTIC, OR EARTHEN AND PORCELAIN MANUFACTURES.

All those materials which in this chapter have hitherto come under notice are such as are naturally hard, and receive a manufactured form mainly by cutting-instruments. But there is a very large and important variety, in which the substance employed assumes such a soft and pliable state as to be easily wrought either by the hands or by pressing in a mould. This includes the whole range of earthen, pottery, and porcelain productions, from the coarsest product of mere clay or clay and sand, up to the exquisite porcelain of Sèvres or of Worcester. Scarcely any art is clearly traceable up to a more remote antiquity than this. We find traces of its existence in nearly all times and nearly every country. That a mass of clay, when moist, may be easily moulded into form; that this clay, when exposed to the heat of a kiln or oven, may be baked to a state of great hardness; and that when thus baked it has a good deal of durability in its character—are facts which could not long have escaped the notice of nations whose ingenuity was sharpened by daily increasing wants.

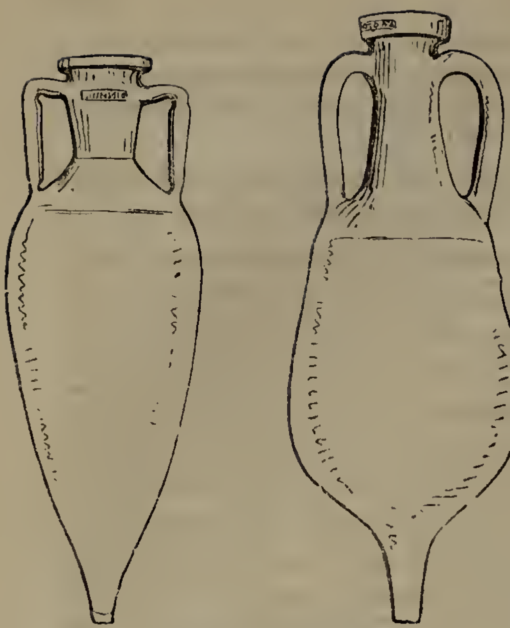
Before watching the processes adopted in the manufacture of such articles, it may be well to say a few words respecting the practice of the art in a few of the chief countries, ancient and modern. In the wood-cuts illustrating this work, from p. 285 to p. 293 (Fig. 1147 to Fig. 1193), will be found several illustrations of the pottery of different countries. Amongst them are a few which do not strictly belong to this class, since they are sculptured in stone rather than modelled in clay; but they are given here to show the sort of models from which the ancient potters sometimes worked. Such, for example, is the beautiful "Warwick Vase" (Fig. 1164), one of the finest things of the kind in existence. This specimen of ancient art was dug up from the ruins of the Emperor Hadrian's villa at Tivoli, and was sent to England by the late Sir William Hamilton in 1774. It is formed of white marble, and is thought to be the work of Lysippus, a Greek sculptor, who flourished in the time of Alexander the Great. The vase, which is capable of containing a hundred and sixty-three gallons, is nearly hemispherical in shape, with a deep reverted rim; and the whole surface is adorned with very graceful sculptures in bas-relief. Some of the Greek urns given in our cuts are similarly cut in marble. Of the far-famed "Portland Vase" (Figs. 1178, 1179) we shall have to speak presently.

Ancient Egyptian and Oriental Pottery.

The investigations of Rossellini and Wilkinson at Thebes and other parts of Egypt have brought to light numerous indications of the potter's art at a remote period in that country. Many of the tombs and other buildings of Upper Egypt are covered with paintings, in that rude and ludicrous style which has been made familiar to most visitors to the Egyptian Room at the British Museum. The arts and manufactures form a favourite class of subjects in these paintings; and however defective the perspective and general drawing may be, there is sufficient to convey a tolerably good notion of the subject intended.

Sir J. G. Wilkinson ('Manners and Customs of the Ancient Egyptians') says, that all the processes of mixing the clay, and of turning, baking, and polishing the vases, are represented in the tombs of Thebes and Beni-Hassan. The Egyptian potters frequently kneaded the clay with their feet; and after it had been properly worked up, they formed it into a mass of convenient size with the hand, and placed it on the potter's wheel, which seems to have been much the same as that of modern times, except in being turned by hand. The various forms of the vases were made out by the finger during their revolution; the handles, if they had any, were afterwards affixed to them; and the devices and other ornamental parts were traced with a wooden or metal instrument, previous to their being baked. They were then suffered to dry, and for this purpose were placed on planks of wood; they were afterwards arranged with great care in trays, and carried, by means of a kind of yoke, borne on men's shoulders, to the oven.

Many of the vases, bottles, and pans of ordinary quality were very similar to those made in Egypt at the present day; and they seem to have had a great variety of Coptic names applied to them. "Coptos and its vicinity," says this writer, "were always noted for this manufacture; the clays found there were peculiarly suited for porous vases to cool water; and their qualities are fully manifested at the present day, in the *goolleh* or *bardak* bottles of Quench. That the forms of the modern *goollehs* are borrowed from those of an ancient time is evident, from the fragments found amidst the mounds which mark the site of ancient towns and villages, as well as from the many preserved entire; and a local tradition affirms that the modern manufacture is borrowed from, and has succeeded without interruption to, that of former days. . . . The Egyptians displayed much taste in their gold, silver, porcelain,



1180.—Greek Amphoræ.

1181.—Porcelain Plates.

1182.—Peruvian Jar.

1179.—Figure at the bottom of the Portland Vase, British Museum.

1183.—Ancient Egyptian Earthen Vessels.

1184.—Peruvian Jar.

1185.—Peruvian Jar.

1186.—Peruvian Jar.

1187.—Peruvian Jar.

1188.—Etruscan Vase.

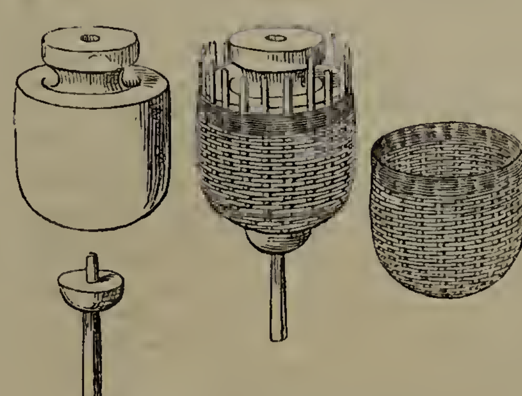
1189.—Etruscan Vase.

1190.—Etruscan Vase.

1197.—Burmese Cup.

1191.—Group of Vessels. (From Specimens found in Roman Burial-places in Britain.)

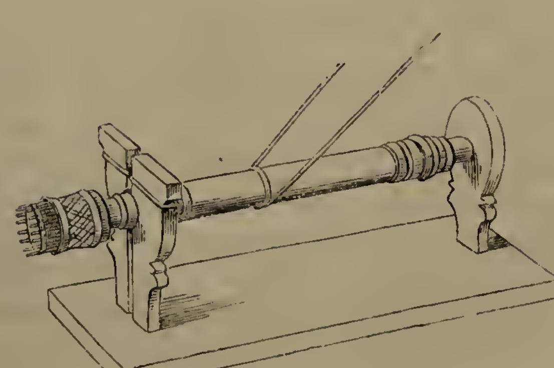
1192.—Grecian Vase.



1195.—Varnished Ware of the Burmese.

1193.—Peruvian Jar.

1194.—Moulds for Porcelain Casts.



1196.—Burmese Lathe for varnished Ware.

and glass vases; but when made of earthenware, for ordinary purposes, they were sometimes devoid of elegance, and scarcely superior to those of England before the classic taste of Wedgwood substituted the graceful forms of Greek models for the unseemly productions of our old potteries. Though the clay of Upper Egypt was particularly suited to porous bottles, it could not be obtained in a sufficiently pure quality for the manufacture of vases like those of Greece and Italy; in Egypt, too, good taste did not extend to all classes, as in Greece; and vases used for fetching water from a well, or from the mill, were frequently of a very ordinary kind, far inferior to those carried by the Athenian women to the fountain of Kallirhoë. The Greeks, it is true, were indebted to Egypt for much useful knowledge, and for many early hints in art, but they speedily surpassed their instructors in taste, and improved on the information they had acquired; and in nothing, perhaps, is this more strikingly manifested than in the productions of the potter."

The same authority informs us, that when the Egyptians gave an entertainment, one of the most usual preparations consisted in decking the apartments with vases. The wealthy had vases of hard stone, alabaster, glass, ivory, bone, porcelain, bronze, silver, or gold; while those of more humble means were obliged to content themselves with vases made of glazed pottery or of common earthenware. Many of these ornamental vases were very graceful in form. Some of the most elegant specimens which have been found at Thebes are supposed to have been wrought so far back as fifteen hundred years before the Christian era, at a time when almost every other country was (so far as is now known) in a state but little removed from barbarism.

The *amphora*, or wine-vessel (of which several representations are given in the wood-cuts), appears to have been borrowed by the Greeks from the Egyptians, and by the Romans from the Greeks. It was an earthen vessel employed in the wine-manufacture, and is represented very frequently in the Egyptian paintings relating to the vintage. It appears from these paintings, that after the juice had been expressed from the grape, and had fermented, it was taken out in small spouted vessels or ladles, and poured into earthen jars or amphoræ; after remaining for some time in this state, the amphoræ were closed with a lid resembling an inverted saucer, and cemented with liquid clay, pitch, gypsum, mortar, and other composition. The amphoræ were then placed upright in a cellar, being ranged in successive rows, the innermost set resting against the wall, and in its turn acting as a support to the others. This arrangement bears a remarkable resemblance to the setting of the sugar-moulds in a refinery, where the sharp apex of the mould (not very different from that of the amphora) would be unable to bear it upright without some other support. (See Fig. 24, in a former chapter.)

With respect to the "potter's wheel," by which a circular form is given to clay vessels, some discussion has taken place concerning its inventors and the date of the invention. Wilkinson says:—"It is impossible to fix the period of the invention of the potter's wheel; and the assertion of Pliny, who attributes it to Coroebus the Athenian, is not only disproved by probability, but by the positive fact that it was known at the earliest epoch of Egyptian history of which the sculptures have been preserved, previous to the arrival of Joseph, and consequently long before the foundation of Athens."

Dr. Kitto, in his Notes to the 'Pictorial Bible,' makes the following observations on Jeremiah xviii. 3:—"'Then I went down to the potter's house, and behold, he wrought a work on the wheels.' The original word rendered 'wheels' is literally 'stones;' and so the Seventy have it in the present text. In Exodus i. 16, the same is rendered 'stools;' and so, or rather 'seats,' the Arabic and some other versions have here. But the Chaldee, Syriac, and Vulgate have 'wheels,' as in our version. There is no question that 'stones' is the *literal* meaning; and we incline to think that the potter's wheel is really intended, and that it is called a stone either because it was made of stone, or because its horizontal rotatory action resembled that of the upper millstone. Some interpreters have been induced to reject the 'wheel' interpretation, because Jeremiah lived before Anacharsis, who is said to have invented the potter's wheel. Such a reason has *now* little weight, particularly as the paintings of the ancient Egyptians, who were famous for their potteries, show the same wheel in operation, the use of which is still retained in the country, and the form of which is so clearly shown by our engraving (Fig. 1209) as to render any particular description unnecessary. It will be seen that, as in common, it consists of an horizontal wheel fixed on the top of a stake, the lower part of which falls into a pit, in which stands the potter, who gives the necessary motion to the wheel with his feet, while he works the clay with his hands. This mode of working is very general among the Oriental potters, and seems to agree very well with the description in Ecclesiasticus, which is of considerable interest:—'So doth the potter, sitting at his work, and turning the wheel about with his feet, who is always carefully set at his work, and maketh all his work by number: he fashioneth the clay with his arm, and boweth down his strength before his feet; he applieth himself to lead it over; and is diligent to make clean the furnace.'—(Ch. xxix. v. 29 and 30.) It is observable that the clause rendered 'boweth down his strength before his feet' is read in the margin 'tempereth with his feet;' and it is a fact that the Oriental potters temper their clay by treading it with their feet; and this is depicted among the operations of the potter in the paintings of ancient Egypt."

Greek Vases and Pottery.

The Greeks were distinguished for the elegance of the forms and devices adopted by them, whether in the structure of a temple, a statue, or a vase. A Grecian vase is to this day regarded as a model in such respects, and shows that the higher branches of art were combined with the labours not only of the carver of a stone vase, but with those of the potter.

There still fortunately remains at hand the means of testing the skill of the Greeks in such matters in the unequalled "Portland" or "Barberini" vase, in the British Museum. This vase is not an example of pottery or porcelain manufacture, and, in so far, does not belong immediately to our subject; but it serves well as an illustration of the taste which was brought to bear on the constructive arts generally. This vase was discovered about the middle of the sixteenth century, enclosed in a sarcophagus, within the monument of the Emperor Alexander Severus and his mother Julia Mammæa, commonly called the Monte del Grano, about two miles and a half from Rome. Both the vase and the sarcophagus remained at Rome as choice specimens of ancient art for more than two centuries, and the sarcophagus still remains there; but the vase fell into the hands of Sir William Hamilton in the latter part of the last century, and was from him purchased by the Duke of Portland, whose successors have deposited it, on loan to the nation, in the British Museum,* where it has been long known by two different names: the "Barberini," from the Roman family in whose possession it long remained; and the "Portland," from the English nobleman who placed it in the Museum.

The Portland vase is believed on all hands to be the work of a Grecian artist; though it is not known by whom or at what period it was formed. Some antiquaries date its execution at several centuries before the Christian era; but be its age what it might, the surprisingly perfect state in which it was discovered in the Roman tomb and in which it remained until the recent injury, has testified both to the skill of the construction, the excellence of the materials, and the care with which it had been preserved. When the Duke of Portland gave a thousand guineas for this vase, he procured a specimen of ancient art which was almost as unequalled for the excellence of its preservation as for its intrinsic merit. It had not been long in England before the attention of modellers and others was directed to it, with a view to the dissemination of copies or representations of it. A gem-engraver, named Pechler, took a mould from it before it was brought to England; and from this mould sixty casts in plaster of Paris were taken by Mr. Tassie, who then broke the mould. In a future page we shall have to speak of Wedgwood's imitation of the vase in porcelain: an imitation of great merit and beauty, but still far behind the original.

The following description of the vase is given in the Penny Magazine:—"Its dimensions are small, its height being only about ten, and its diameter at the broadest part only six inches. But its shape is very elegant; the swell of the lower and central portion diminishes gradually to a narrow neck, and that again gracefully opening towards the lip, like an unfolding flower. It is supported by two handles, inserted at the concave or narrow part. The material is a dark but transparent blue substance, undoubtedly a sort of vitrified paste or glass, although long supposed to be some species of stone. Upon this the figures, formed of a delicate opaque white substance, are laid in bas-relief; and so firmly are they united to the ground upon which they are thus fixed, that they seem rather to have grown out of it, and to have been a part of itself, than to be fastened on by art. It is difficult, indeed, to conceive by what process the union between the two substances was effected. They must, of course, have been brought into contact when both were in a soft state, and then apparently they were run together by heat. If the action of fire, however, was employed for this purpose, it has not injured the finest line in any of the figures. Every stroke is as sharp and unbroken as in the most finished delineations that were ever drawn by the pencil, or cut by the graver, or struck from the die. Of the scene represented, no satisfactory explanation has yet been given, and therefore any description of the figures would be little better than a catalogue of unconnected particulars. But we may say in general that they are fashioned with admirable grace and animation, and are full of expression in every look and attitude. It is impossible not to feel that there is great dramatic force and pathos in the sketch, even without being able to interpret it completely." In Fig. 1178 is shown the appearance of the vase viewed on one of its sides; while Fig. 1179 is a representation of the device on the bottom.

To return, however, to Greek vases and other vessels made of pottery or earthenware. These vases were generally coloured, since the material of which they were made never presented a white tint; and the Greeks were not a people to be content with the dusky nameless colour of common clay. There was generally colour applied after the vase was made; and according as this colour was of one or of more tints, so was the vase called *monochrome* or *polychrome*, that is "one-coloured" or "parti-coloured."

The monochrome vases, after being formed by the hand of the potter, are supposed to have been thus coloured:—The pattern or device was formed in the clay or plaster by means of outlines upon paper, which outlines were marked by small holes. This paper being laid upon the surface of the vase, finely-pounded charcoal, rubbed over the pattern, traced the form of the figure by falling through the holes. Another paper having the places cut out where the colour was to be applied, was then used, in the same manner as for modern "stencil"-painting. The painting of the vase was executed either by the parts forming the picture being left untouched through the cover of the pattern, and the other exposed parts coated with black paint; or cavities cut out for the figures were filled with the black or white colour, and the rest of the vase possessed the natural hue of the baked clay. The latter is the method believed to have been more extensively adopted. The polychrome vases were painted much in the same way; there being, however, an additional number of pattern-papers, each one belonging to a particular colour in the device.

With regard to the admixture of colours, it is thought that the first specimens were simply outline delineations, without any new colour added to the colour of the clay; and that black was afterwards used to represent shadow. Some of the early writers speak of the red colour being produced by cinnabar or vermilion, and that a cheaper red was formed of minium or red-lead. Sometimes the figures were black, and the nerves picked out with a white, for effect; sometimes the figures are of two colours, black and dark red, the muscles of the body and plaits of the vest being represented by scratches only; while other specimens have red figures upon a black ground; the effect being heightened, in the earlier periods of the art, by a rudely scratched outline; but at a later time, by a more careful delineation, often tinted with other colours.

The devices on these vases have varied as much as the mode of painting. In the earlier specimens they are either historical events, or the employments of man in hunting, &c. At a later time the employments of the bath, of the toilet, of dancing, or of pastimes, were the subjects chosen. Flaxman has remarked that the drapery on the figures of the best of these vases is admirable for the skill with which the folds of the particular kind of textile material employed is imitated. In the finer and more transparent kinds, their texture and consequently their folds strongly resembled our muslin, and are peculiar to the more elegant and delicate female character, such as nymphs, goddesses, &c. —so often forming component features of a Grecian picture.

Etruscan and Roman Pottery.

The Etruscans, a nation who preceded the Romans in the occupation of central Italy, have left behind them specimens of great beauty in the form of earthen vases. The visitors to the British Museum have an opportunity of seeing a large collection of them, sufficient to show that great excellence of design was often exhibited, especially in the *form* of the vessels. Many of the vases known as Etruscan are so much like those attributed to the Greeks, that some antiquarians think they are really of Greek origin; while others think that the inhabitants of Etruria formed them. It has been observed by one writer that the real Etruscan vases are made of clay inferior to that of the Greeks, that the colours used are duller, and the designs less skilful. These, however, are disputed points; but it is known that vases of fine workmanship are frequently dug up in that part of Italy which anciently constituted Etruria.

There are three varieties of Etruscan vases: those in which the paintings are of a dusky red colour upon a yellow ground; those which have black paintings upon a reddish yellow ground; and those which have reddish-yellow figures and ornaments upon a black ground. The first of these is said to have been borrowed from the Egyptians, and to have devices of harpies, sphynxes, griffins, &c.; while the last of the three styles represents gods, heroes, and mythological

* It will ever remain matter for regret, that in the nineteenth century such an act of wanton barbarism should have been committed as the destruction (or at least the fracture) of this vase, by one who had shared with the public generally the privilege of inspecting it in the rooms of the British Museum. An ingenious and unweariedly-patient artist is said to have re-united the scattered fragments so skilfully as to render the damage scarcely visible; but this does not lessen the feeling of humiliation that the exercise of such skill should have been required in our own country and at our own day.

subjects; the second style being intermediate between the two. There are peculiarities of workmanship in each of these three styles. Mrs. Hamilton Gray says: —"You will rarely see a black figure easy, natural, and graceful, however exquisite may be the beauty of its workmanship; and you will seldom be able to trace in a red figure that peculiar stiff and rigid quaintness which is characteristic of the most ancient Etruscan art. Those black figures which have a stately and flowing ease are on vases of a very inferior material and execution, and belong to the period of the decay of art, like the roughly-drawn red figures which are so common."

The mode in which these vases (of which three fine specimens are sketched in Figs. 1188, 1189, 1190) are supposed by D'Harcanville to have been made, is as follows:—"The clay, which is of a very fine quality, they procured from the banks of the Vulturnus, a river of Capua; and, placing it in water, they allowed it to remain until it had become sufficiently pliant to be moulded into any form. They then, by means of the potter's wheel, moulded the clay to the shape required; and, while it was still wet, a coating of iron ochre was applied, which, when heated at the last stage of the process, produced the black colour which generally forms the ground of the vases. The painter then drew in the ground of the figures; and as he did not exercise his art on a plane surface, but on one which was considerably curved, and was obliged moreover to keep the vases upright, as—in the plastic state in which they were at this period of their manufacture—their weight, if placed sideways, would tend to alter their form, we may judge of the great difficulty he had to encounter in producing a continuous and even line. The borders and ornaments then appear to have been put in, and then the vase was placed in a furnace, where the colours were burnt in, and the whole completed."

To pass from the Etruscans to their neighbours the Romans, we have abundant evidence of the practice of the pottery art among that people. In every country where the Romans were settled for any considerable space of time, are to be found specimens of pottery evidently made by them. England is particularly rich in such specimens. Scarcely a year passes without some such coming to light, in the case of excavations going on at any spot where the Romans once had a city or an encampment. Vases and urns formed part of the sepulchral or funereal apparatus among many ancient nations; and a reason is thus found for the existence of so many vessels whose uses might otherwise appear to us difficult to understand. During many of the improvements which have taken place in London within the last few years, Roman pottery has been dug up in considerable quantity. Such pottery (of which, and of other specimens discovered elsewhere, many sketches are given in Figs. 1147, 1157, 1162, 1163, 1191) comprised vases, urns, small statues, lamps, wine-vessels and cups, and other articles of varied form.

In relation to the exercise of the potter's art in England by the Romans, Mr. Porter, in his 'Treatise on the Porcelain Manufacture,' remarks:—"We learn on the authority of Vitruvius, who wrote in the Augustan age, that the Romans then made their water-pipes of potter's clay. This people, who introduced a knowledge of the useful arts practised by themselves wherever their conquests were extended, established potteries in England, where many other articles similar to water-pipes were made. Some of these, about a century ago, were dug up in Hyde Park; they were found to be two inches in thickness, and were fairly jointed together with common mortar mixed with oil. It has been asserted that the ancient Britons were in the habit of making pottery before the invasion of this country by the Romans; and in support of this belief is brought the fact, that urns of earthenware have been taken from barrows in different parts of the kingdom. On the other hand, the concurring testimony of various writers gives reason for supposing that our ancestors were in those days supplied with such articles by the Venetians. Vestiges of considerable Roman potteries are discernible in many parts of the island, and particularly in Staffordshire, on the site of the great potteries which have so long been carried on in that county. In sinking pits for various purposes, remains of Roman potteries have occasionally been discovered there at a considerable depth below the surface. Governor Pownall relates that in his time (1778) the men employed in fishing at the back of Margate Sands, in the Queen's Channel, frequently drew up in their nets some coarse and rudely-formed earthen vessels; and that it was common to find such pans in the cottages of these fishermen. It was for some time believed that a Roman trading-vessel, freighted with pottery, had been wrecked here; but on more particularly examining the spot, called by the fishermen Pudding-pan Sand, some Roman bricks were also discovered, cemented together, so as to prove that they had formed part of some building. Further researches showed that, in Ptolemy's second book of Geography, an island was designated as existing in the immediate vicinity. Such pans as were recovered in a sound state were of coarse materials and rude workmanship—many having very neatly impressed upon them the name of Attilianus; but fragments of a finer and more fragile description of pottery were likewise brought to the surface; and little doubt remains that during the time of the Roman ascendancy in England a pottery was established here upon an island which has long since disappeared, and that the person whose name has been thus singularly preserved was engaged in its management."

The Romans, the Egyptians, and other ancient nations were acquainted with the use of coarse, porous, unglazed earthen vessels in which to cool water or wine for the table. The water or wine was carefully decanted from its sediment into earthen vessels, which were then carried to the top of the house; here the coolness of the night-air caused the liquid, which slowly exuded in minute drops through the pores of the ware, to evaporate; and the liquid became thereby speedily cooled. At a later date the Moors introduced into Spain a sort of unglazed earthen jug, which was employed by them for a similar purpose.

Peruvian and Mexican Pottery.

From time to time there are facts brought to light which show that the early inhabitants of America had made considerable progress in the arts long before the (so-called) discovery of that continent by the Europeans. Mr. Stephens's researches in Central America have elicited wonderful examples of this kind; and there are not wanting scattered indications of a similar state of things elsewhere. A gentleman, about five or six years ago, gave in the 'Penny Magazine' a sketch and description of half a dozen very curious earthen jars which had just before then been dug out of a tomb in Peru. The tomb was designated the "Tomb of the Incas;" and from collateral circumstances these vessels are believed to be far older than the days of Pizarro, Cortes, or Columbus. The six vessels are described separately in the following manner.

The vessel (Fig. 1186) appears to have been intended to hold liquor as a bottle. The figure is in a sitting posture, with the knees up; the head covered with a cap composed of two parts, confined under the chin by a string or band; the face, though rudely formed, exhibited the placid character of sleep or death, the closed eyes indicating one or the other; the mouth is wide, the nose large, the lobes of the ears perforated, and much elongated by the weight of the large ornament thrust through them; the back of the body is enveloped by a mantle or cloak, having a collar quite round the neck, tied at the throat, the ends of the fastening hanging over the breast; there is no appearance of other garments. The limbs are very stiff and badly executed. The figure holds in its hands a fruit bearing some resemblance to a pine-apple, in which is a small orifice to admit of the liquor flowing in at the larger opening. This larger hole is situated on the top of the handle, and there is a figure of a monkey looking into it. The vessel is eight inches high, five and a half from the breast to the lower part of the handle, and the diameter of the base about five. Its colour is dark ash, approaching to black, with some lighter shades. It appears to have been wrought wholly by hand.

A second vessel (Fig. 1184) seems to be a rude representation of a hippopotamus; the head is flat and broad, with a very wide mouth; it has a curious collar partly round the neck; the legs are placed in an unmeaning manner on the sides, much too small in proportion to the rest of the figure. The vessel is between seven and eight inches high, and about as long through the head and body. It is composed of greyish sandy earth, and has been sun-dried to nearly a black colour.

Another vessel (Fig. 1187) more nearly represents a modern pitcher, with a grotesque face raised on its surface, the ears projecting from the sides. It bears marks of having been formed in a mould, and afterwards, whilst the clay was wet, the figures were carved or raised on it. This is supposed, from the wretchedness of the device carved on it, to be either much more ancient than the former two vessels, or executed by a less ingenious artist. It stands obliquely on its bottom, and is about five inches high. A fourth specimen (Fig. 1193) is shaped something like a stirrup, and is of a different colour from the others, being a light red with white stripes painted on the surface: the earth of which it is formed is of a very fine texture.

The jar sketched in Fig. 1185 is an interesting specimen, about six inches high, by rather less in diameter. The colour is black, and there is a greater elegance of design, both in the form and pattern, than in any of the others. The grotesque figure which forms the handle seems to be intended for a monkey. The pattern is carved or indented, instead of being raised in relief; and so far it resembles the "Vitruvian scroll," or the "Grecian fret-work." Whence and how the Peruvians borrowed this pattern, or what was the tie which bound distant nations in ancient times, are questions which it will take learned antiquaries a good deal of investigation to answer.

The sixth and last jar (Fig. 1182) is quite plain, and contains no features requiring notice.

Mr. Stephens, a talented observer, who was sent to Central America on a political mission by the Government of the United States a few years ago, spent his spare time in exploring the ruins of six or eight cities, whose history is a perfect blank, but whose buildings show evident marks of a state of art and civilization very different indeed from that exhibited by the present Indian inhabitants of the district. In the course of these explorations, he repeatedly met with terra-cottas and specimens of pottery, showing that these were among the branches of art cultivated by the unknown dwellers in these cities. Some of these specimens were found deposited in a remarkable way. For instance, in one mass of ruins there were several holes in the ground, leading to subterranean chambers; and one of these openings Mr. Stephens determined to explore. "The opening was a circular hole, eighteen inches in diameter. The throat consisted of five layers of stones, a yard deep, to a stratum of solid rock. As it was all dark beneath, before descending, in order to guard against the effects of impure air, we let down a candle, which soon touched the bottom. The only way of descending was to tie a rope around the body, and be lowered by the Indians. In this way I was let down, and almost before my head had passed through the hole, my feet touched the top of a heap of rubbish, high directly under the hole, and falling off at the sides. Clambering down it, I found myself in a round chamber, so filled with rubbish that I could not stand upright. With a candle in my hand, I crawled all round on my hands and knees. The chamber was in the shape of a dome, and had been coated with plaster, most of which had fallen, and now encumbered the ground. The depth could not be ascertained without clearing out the interior. In groping about, I found pieces of broken pottery, and a vase of terra-cotta, about one foot in diameter, of good workmanship, and having upon it a coat of enamel, which, though not worn off, had lost some of its brightness; it had three feet, each about an inch high, one of which is broken. In other respects it was entire."

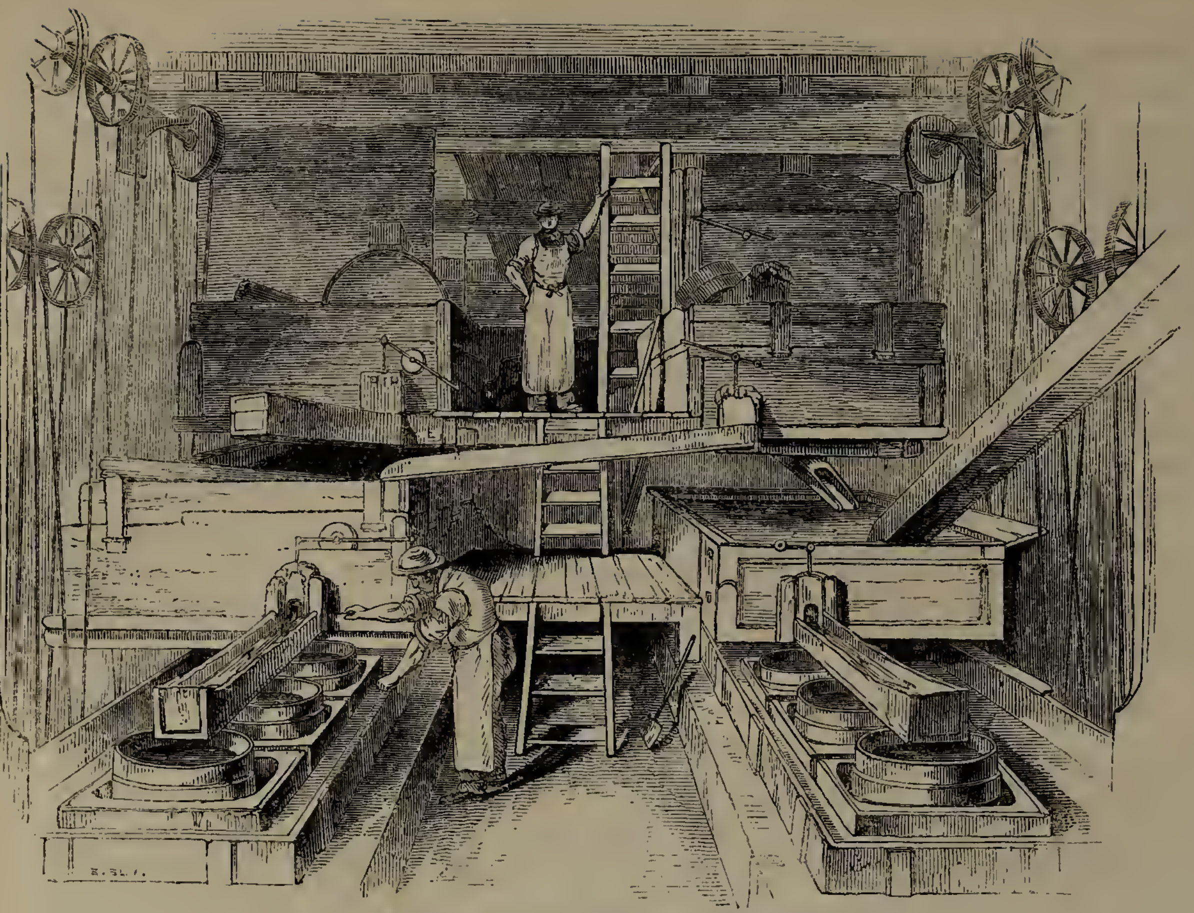
In some of the other subterranean chambers which he explored, the openings were so small that Mr. Stephens, to use his own expression, had to undergo a "severe rasping" against the sides of the opening before his Indians could pull him out. In some instances he found vases and pottery, but not in all. Most of the buildings, or ruins of buildings, were found on or near elevated mounds; and it was near these mounds that Mr. Stephens made his search. He gives an engraving of an elegant vase found near a place called Ticul. On one side of this vase is a border of hieroglyphics, with smaller lines running to the bottom; and on the other is sculptured a figure with a head-dress formed of a plume of feathers, and the hand held out in rather a stiff position. The vase is four and a half inches high by five in diameter. At another spot, in a subterranean hollow where a skeleton was found, was also discovered a large vase of rude pottery, resembling very much the *cantaro* used by the Indians at the present day as a water-jar; it had a rough flat stone lying over the mouth, so as to exclude the earth; it had a small hole worn in one side of the bottom, through which liquid or pulverized substances could have escaped.

One more example of this singular storehouse of curiosities will suffice. At the foot of one of the explored ruins was a vault, faced with cut stone, in which were found a collection of bones and a terra-cotta vase; the vault was not big enough for the body of a man extended, and the bones must have been separated before they were placed there. Mr. Stephens made a bargain with the owner of the ground, by the terms of which they agreed to explore together, and that Mr. Stephens should have all the curiosities found, while the other was to have all the hidden treasure, of the existence of which some reports had been rumoured. The treasure was not forthcoming, for none could be found; but Mr. Stephens met with two vases: one of these was entire, and was graceful in design, well made, and having a good polish on the surface; the other was broken, and though more complicated in form, had no polish on the surface. Another vase previously found on the same spot was a basin-shaped vessel about twelve inches in diameter, supported on three feet, and ornamented and polished at the surface.

Chinese Porcelain.

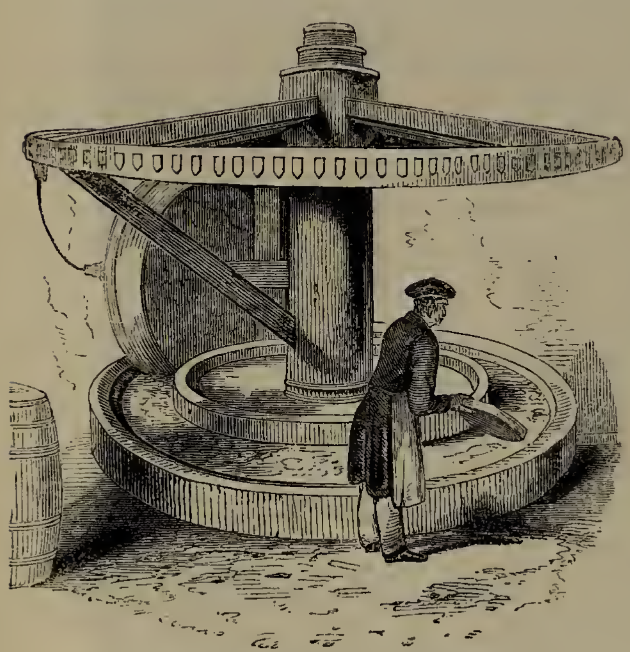
Whatever nation may bear away the palm in respect to earthen vases and urns, the Chinese unquestionably may lay claim to the invention of the beautiful semi-transparent substance called porcelain, and to which we have applied the term "china."

Although there are slight indications of China porcelain having been known in Europe at the time of the Romans, the Portuguese seem to have been the first to make this material generally known in Europe. It was they, also, who gave the name of "porcelain," which is said to have originated thus: there was at that time a sort of univalve shell employed in some parts of the East in lieu of money, in the same manner that cowry-



1198.—Mill-room, where the Ingredients for Pottery are mixed.

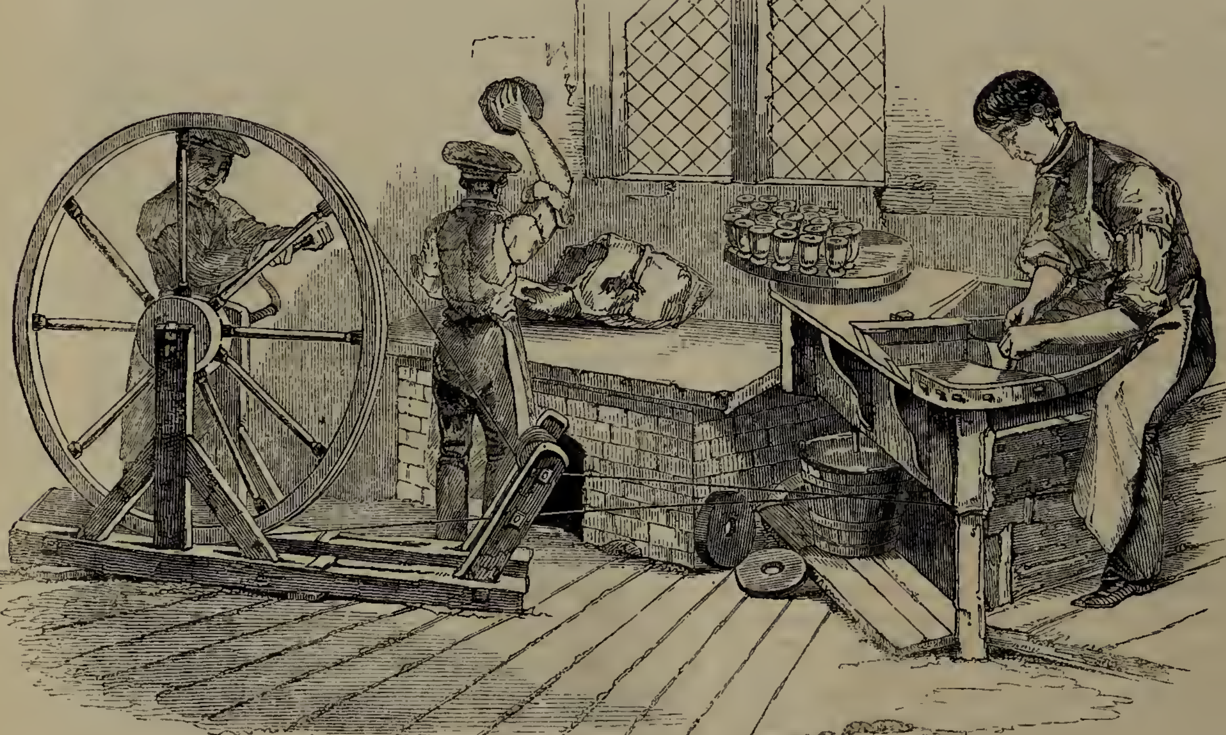
1199.—Flint-crushing for Pottery.



1201.—Grinding Flint and Clay for Pottery.

1200.—Wedgwood.

1202.—Fixing Handles to Cups and Jugs.



1203.—Arrangement of the modern Potters' Wheel.

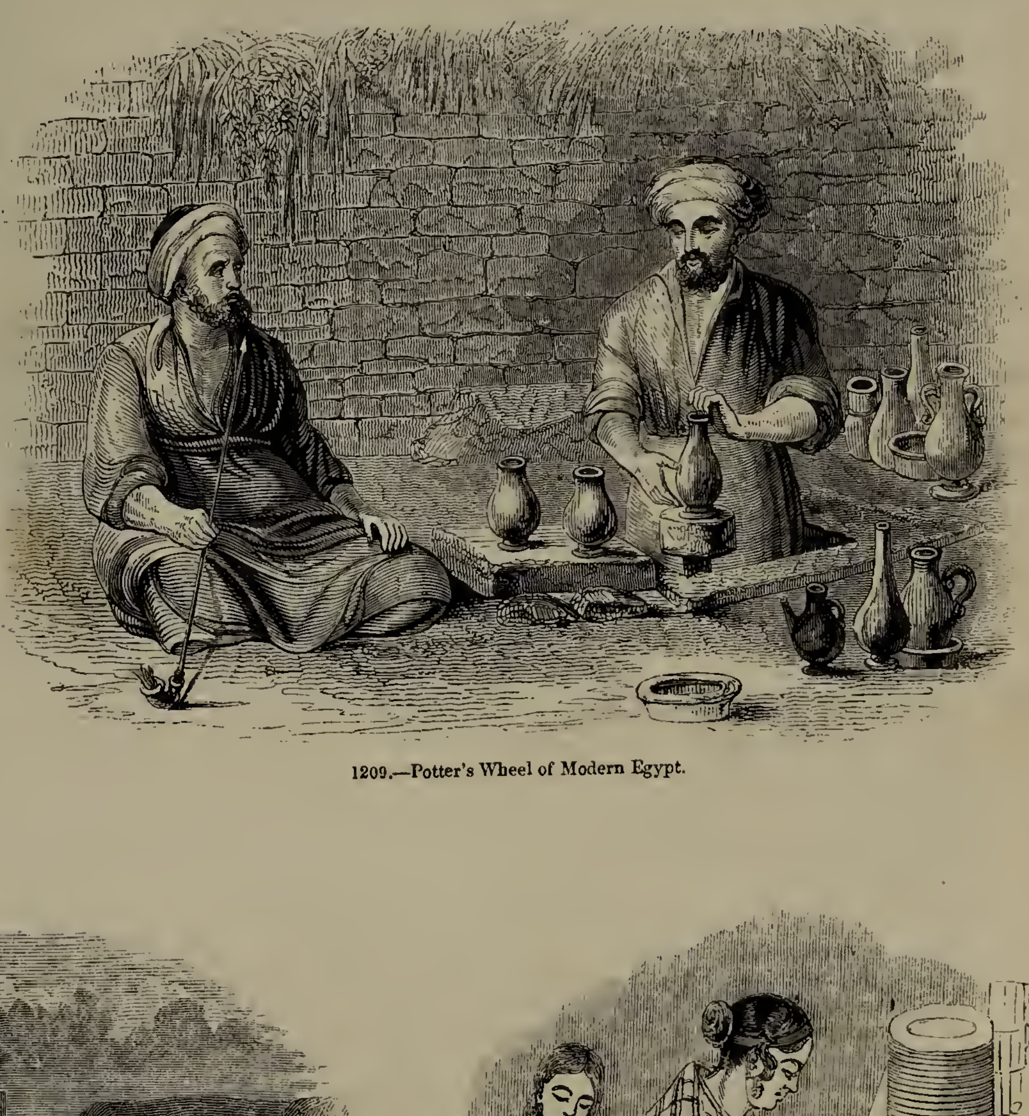
1204.—Plate-making.

1205.—Placing Earthenware in the "Biscuit-kiln."

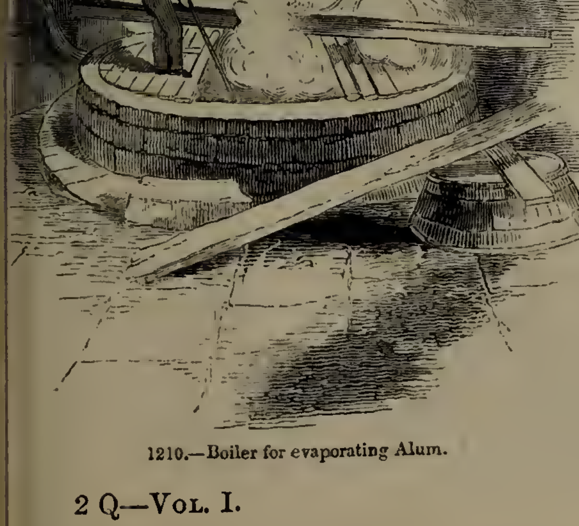
1206.—Putting manufactured articles into "Seggars."

1207.—Pottery "Turning."

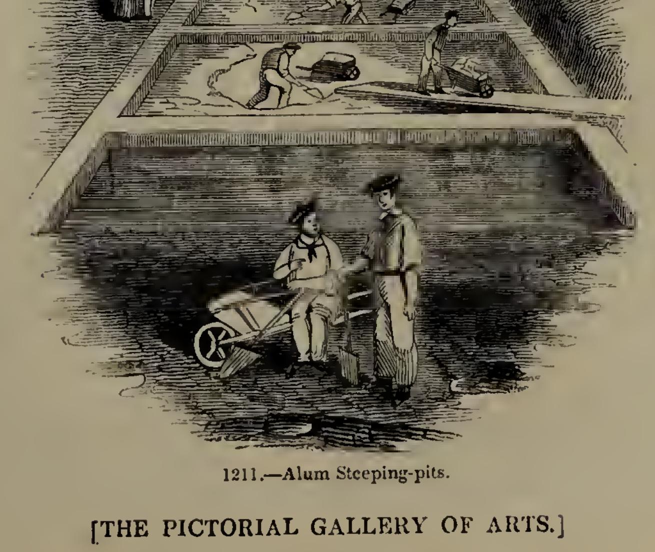
1208.—Printing Blue-ware.



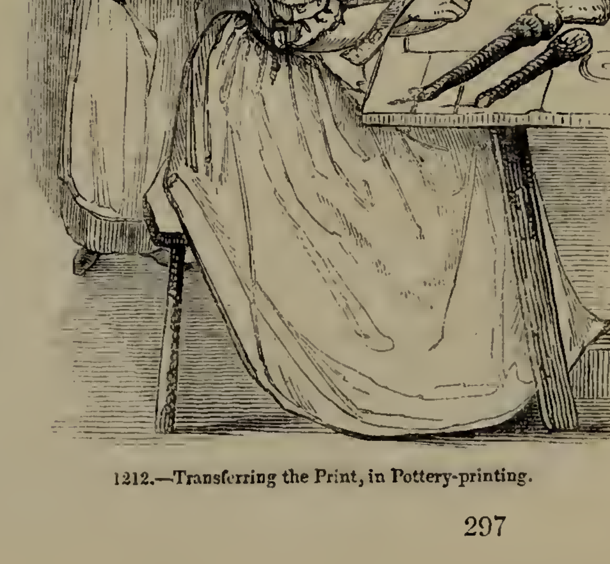
1209.—Potter's Wheel of Modern Egypt.



1210.—Boiler for evaporating Alum.



1211.—Alum Steeping-pits.



1212.—Transferring the Print, in Pottery-printing.

shells are at the present day; the curved or gibbous shape was supposed to resemble that of a "porcella," or little pig, and the shell thereupon obtained this name; the ware of the Chinese resembled in smoothness and texture the surface of these shells, and hence obtained the name of "porcellana," from whence our term porcelain. Other etymologists, however, state that "porcellana" is the Portuguese name of a kind of cup; and that when that people spoke of Chinese porcelain they merely intended to allude to Chinese cups.

But though the Chinese vessels themselves were brought to England, the material of which they were made was long matter of doubt, and gave rise to stormy discussions. Two learned men, Scaliger and Cardan, are said to have agreed in opinion that the ware was made from a mixture of broken egg and sea-shells, which were preparatively buried in the earth for a hundred years. About the beginning of the seventeenth century an enterprising Jesuit, named D'Entrecolles, succeeded in so far eluding the vigilance of the authorities as actually to visit the places in China where the manufacture was carried on; he wrote home word to Europe that Chinese porcelain was made of a mixture of two varieties of earth or clay found in China. Experiments subsequently made in France and Germany proved this to be the case: the two earths are called in China "kaolin" and "petuntse," the former being a sort of felspar clay, and the latter a kind of flint.

Mr. Davis states:—"The government of China, for more than a thousand years past, has paid much attention to the manufacture of porcelain, and especially to that at *King-te-chin*, which pertains to the chief city Jaou-chow-foo. The Emperor Kieng-loong sent a person from Peking to make drawings of the whole process in its details. In a voluminous Chinese work, the subjects of these drawings, which were twenty in number, are described at length. They commence with the process of procuring the materials and making the paste; then is represented the business of preparing the ashes for the glazing, and mixing them with the silica, so as to form a thick liquid. Earthen cases are provided in which to bake the ware, the round portions of which are turned in a lathe, and the others made in a mould. The subject of another picture is the selection of the "blue material," which is supposed to be cobalt. After being turned in a lathe, or formed by a mould, the unburnt "biscuit" (as workmen call it) is finished by smoothing and paring off all inequalities by the hand, the bits taken off being pounded and worked to a milky consistence, to be used by the painters. In painting the ware, one set of people design the outline, and another fill in the colours; and the Chinese say that this division of labour is to "concentrate the workman's hand, and not divide his mind." It is said that, previous to baking, the same specimen of ware passes through twenty hands, and that, before being sold, it has gone through more than double that number. The pictures proceed to represent the baking of the ware in open and in close furnaces; and, when it is completed, the process of binding it with straw and packing it in tubs for sale. The whole series of drawings concludes with the ceremony of sacrificing and giving thanks to the god of the furnaces; and this god, according to D'Entrecolles, owed his origin to the difficulties encountered by the workmen in executing some orders from Peking on account of the Emperor. Several models were sent from thence of a shape and size which defied all the efforts of the people to imitate them; and though representations were made to that effect, these served only to increase his majesty's desire to possess the specimens required. With a view to meet the Emperor's inclination much money and labour were spent, and both rewards and punishments held out to the people employed, but all in vain; when one of the workmen, reduced to despair by the result of his unavailing efforts, threw himself into the red-hot furnace, and was instantly consumed. The story says that the specimens then baking came out perfectly fine and conformable to the model; and from that time hence the unfortunate victim passed for a divinity, becoming the god of the furnaces."

Before proceeding to the European modes of making pottery, it may be well briefly to notice the *varnished ware* of the Burmese, a manufactured article which serves many of the purposes of pottery in that country.

This ware, in its best state, has been likened to very fine papier-maché, being thin and light; and it is so flexible, that the opposite sides of a cup may be pressed together without cracking even the varnish of the surface; the cup, too, recovering its former shape on the pressure being removed. The surface is sometimes coloured with a shining black, sometimes with a vermilion red; but more frequently it exhibits a yellow or green ornament on a red ground, or a red ornament on a black ground. Some specimens present a device in gold: in short, the varieties of decoration are as numerous as the purposes to which the ware is applied, and which comprise cups, dishes, boxes, trays, baskets, and buckets. In the Museum of the Asiatic Society a set of specimens is deposited, exhibiting all the successive stages in the manufacture.

In the first place there is a wooden form or mould (such as at the left hand of Fig. 1195), and this is covered with straps of bamboo so woven as to form a basket, the framework of the intended cup. The weaving is very thin and fine, and delicately executed. The basket is shown in the same cut both off and on the wooden mould. The cup is then coated on the outside with a peculiar varnish which is prepared from a juice exuded by an Oriental tree; the trunk of which is pierced for this purpose in much the same way as the trunks of those which yield caoutchouc, turpentine, and balsam. The varnish is applied to the surface of the basket by means of a brush made of cocoa-nut husk; when first laid on it presents a lightish brown colour, but a subsequent process of rubbing with the hand turns it to a fine black. The varnished basket is carefully shut up in a box to exclude the dust, and then deposited in a deep cold vault, in order that the drying or setting of the varnish may take place gradually. After this the cup is coated with a thick black paste, which is intended to stop up all holes in the basket-work, and to give it body or substance. The powder of calcined bones, the carbonized husk of rice, the fine sawdust of teak-wood, are among the ingredients used in this paste; and the paste, when made, is laid on with the fingers of the workman.

When the cup is dry, after this application of paste, the interior is turned smooth by means of the lathe shown in Fig. 1196. This rude kind of lathe consists mainly of a horizontal roller, which is turned backwards and forwards with a stick and leather string. At one end of it is a hollow cylinder of coarse basket-work; and into this cylinder the cup is inserted, so as to be able to rotate with the roller. The workman smears the inside of the cup with ochre mixed with water; and then, while the cup is rotating, he holds against its inner surface a piece of pumice-stone, whereby the roughnesses are speedily rubbed down: the basket-work structure of the cup shows itself through the paste, but without detriment to the smoothness of the surface produced. The cup is then removed, and refixed to the lathe in such a way as to leave the outer surface exposed: this surface is rubbed down smooth in the same way as before. Both surfaces are next coated thickly with varnish; and this varnish, when dry, is rubbed with a piece of smooth sandstone, then with a rag dipped in charcoal and water, and lastly with a moist cloth.

The cup has by this time attained the state of a very smooth japanned ware, uniform in surface inside and out. Then ensue the processes for giving it a decorative appearance. A high polish is imparted by rubbing the surface successively with different materials, applied sometimes by means of a piece of cloth, and in other instances by the hand. Some of the cups produced present a jet-black colour; some are red, painted with a mixture of vermilion, oil, and varnish. Many of them are engraved on the surface in a curious manner. The artist holds the cup on his knees with his left hand, turns it round gradually, and engraves the surface by means of a needle tied to a stick. In some specimens the engraving is effected on black ware, and the hollows are filled up with vermilion; while in others there are figures left in relief, by cutting away the varnish around them. Another mode is to engrave a device on a red cup, and fill up the hollows with yellow and green varnish. Fig. 1197 represents a cup prepared in this way.

Some of the cups have bas-relief ornaments on the surface. These ornaments are made of a stiff paste which is pressed into tin moulds; and, when dry, they become as hard as wood. Some of the cups are gilt; and by varying the gilding, the employment of raised figures, the engraving, and the colours employed, a very great diversity is produced.

There is something akin to these Burmese vessels in the japanned ware alluded to by Mr. Davis:—"The *lackered* or varnished ware of the Chinese, though by their own admission inferior to that of Japan, is occasionally, in the hands of the best workmen, a beautiful manufacture. It varies, however, from the polished jetty surface of the magnificent folding-screens, sometimes brought home to this country, down to the articles of daily use made for the Chinese themselves, in the shape of tubs, trays, and wash-hand basins, with the ornamental parts of their buildings. These coarser varieties are derived from the nuts or seeds of the *Dryandra cordata*; while the finer kind is obtained from the gum of a species of *Rhus*. The chief expense of the manufacture arises from the care with which the consistence of the varnish must be regulated in laying it on, and the number of repetitions required in the finer kinds of ware, of which each successive coat must be allowed a considerable time to dry before it is again touched. When first introduced to Europe this manufacture was highly appreciated, and the export from Canton considerable; but the improvements in our own productions have reduced the quantity now in demand to something very small."

The Staffordshire Potteries.

We may now watch a little more closely the successive stages in the manufacture of pottery, properly so called.

In doing this it is impossible to avoid being struck with the remarkable appearance presented by the pottery district of North Staffordshire. This district is known everywhere by the designation of "The Potteries;" and well does it deserve the name; for throughout a district ten miles in length by two or three in breadth, establishments for the manufacture of pottery and earthenware meet the eye at every turn. Throughout the towns of Burslem, Tunstall, Hanley, Shelton, Etruria, Stoke, Fenton, Lane End, and smaller places contiguous to them, almost every person derives subsistence, directly or indirectly, from this manufacture. Seventy thousand persons are supposed to be directly dependent thereon; and the entire commerce of the district has relation, in one way or other, to pottery.

It is not clearly known at what period the making of pottery was commenced in Staffordshire; but if the surmise be correct that the remains of a Roman pottery-work have been there discovered, a germ must have existed which was not unlikely to lead to the revival of the art in a later day. Dr. Plot, in his 'History of Staffordshire,' states that the manufacture was carried on at Burslem before his time; and that there were, in the neighbourhood of that town, different kinds of clay suitable for the different kinds of ware made.

There were three or four successive and very curious stages in the history of the advancement of the Staffordshire potteries.

The first related to the "glazing" of vessels by salt. According to the current story, at Stanley Farm, situated not far from Burslem, a servant was boiling in an earthen vessel a strong lye of common salt, to be used in curing salt. During her temporary absence the liquor boiled over, and some ran down the sides of the vessel, covering the surface with a liquid which on cooling appeared as a glaze. Mr. Palmer, a potter of the neighbourhood, being made acquainted with the fact, speedily made profitable use of it, and established the manufacture of the common brown glazed ware. There were salt-beds in some of the neighbouring districts; and this circumstance led to the extension of the manufacture to spots farther removed from Burslem.

The next incident also related to the glazing of vessels. Two brothers, named Elers, came from Nuremberg in 1690, and settled at Bradwell, where they made an improved kind of red ware, and introduced the art of glazing pottery by throwing common salt into the oven at a certain stage of the baking. Every precaution was used by the brothers to keep their processes secret; and it is probable that this circumstance, joined to the success of the strangers, induced their neighbours to persecute them so as to compel them to leave the place. Their secret, however, was left behind them. A man named Astbury, feigning to be of weak intellect, and assuming an appropriate vacuity of countenance, obtained employment at the Bradwell works: he submitted to all the drudgery and jeers cast upon him; and was by this course of proceeding enabled, unperceived and unsuspected, to acquire a knowledge of all that was done in the manufactory. The method of glazing was revealed to the other potters, and was soon extensively adopted.

A third incident related to the introduction of white stone ware, also attributed to Astbury, but at a later period. Astbury, it is said, while travelling to London on horseback in the year 1720, had occasion, at Dunstable, to seek a remedy for a disorder in his horse's eyes; when the ostler at the inn, by burning a flint, reduced it to a fine powder, which he blew into them. The potter, observing the beautiful white colour of the flint after calcination, instantly conceived the use to which it might be applied in his art.

The next material stage in the advancement arose out of the energy and talent of Josiah Wedgwood. He was one of those men who occasionally arise, with the proper natural gifts and at the proper time, to give to the subject of their thoughts an importance and value which it did not before possess. He was of humble origin; and the kinds of ware made in Staffordshire before his time were of humble merit; but he succeeded in giving to the productions of his native county a celebrity which has never since passed away. Mr. Porter says of him:—"This extraordinary man owed none of his success to fortuitous circumstances. Devoting his mind to patient investigation, and sparing neither pains nor expense in accomplishing his aims, he gathered round him talented artists from different counties, and drew upon the stores of science for aid in pursuing the objects of his praiseworthy ambition. The early and signal prosperity whereby his efforts were attended served only as a motive urging him forward to new exertions, and as the means for calling forth and encouraging talents in others, in a manner calculated to promote the welfare of his country. Previously to his time, the potteries of Staffordshire produced only inferior fabrics, flimsy as to their materials, and void of taste in their forms and ornaments—the best among them being only wretched imitations of the grotesque and unmeaning scenes and figures portrayed on the porcelain of China. But such have been the effects resulting from the exertions and example of this one manufacturer, that the wares of that district are now not only brought into general use in this country, to the exclu-

sion of all foreign goods, which had before been largely imported; but English pottery has since been sought for and celebrated throughout the civilized world, and adopted even in places where the art was previously prosecuted. . . . . It is not among the least of Mr. Wedgwood's merits, that he overcame the disadvantages of a defective education; and, amid the calls of an incessantly active life, found time wherein to school his mind in all the discipline necessary for investigations purely scientific. The ample fortune which he acquired was ever ready for promoting the spread of knowledge, encouraging the efforts of genius, and lessening, as far as possible, the sufferings of his fellow-creatures. His charities, public and private, and especially in his own district, were exemplary and consistent. He gave life to many objects of public utility. The Trent and Mersey Canal was undertaken and accomplished through his influence; and by the benefits it has produced to the district, and to its proprietors, has fully approved his wisdom in its promotion."

Wedgwood brought into use many kinds of earthenware. One was designated by him "*table-ware*," or "*queen's ware*," having a dense and durable substance and a brilliant glaze. Another was a "*terra-cotta*," or burnt earth which could be made to imitate porphyry or granite. A third was "*black ware*:" this was very hard, highly polished, and capable of resisting great heat and strong acids. A fourth was called "*white porcelain biscuit*," which presented a smooth wax-like appearance. Another was "*bamboo*" ware, differing from the last-mentioned only in colour. Another kind called "*jaspar*," besides being beautifully white and delicate, possessed the property of receiving mineral colours in the same way as if it were glass.

There were other varieties of ware, also, which Wedgwood either invented or greatly improved. Besides the ware for general use, he produced very beautiful and costly articles, professedly in imitation of the finest models. The Portland vase (to which allusion has already been made) attracted his notice as soon as it was brought to England. He bid very largely for it at an auction; and only consented to its being "knocked down" to the Duke of Portland on condition of having the loan of it to copy. He employed the best modellers and workmen in every branch to imitate it; and succeeded in producing fifty admirable copies of it, which were sold at fifty guineas each. The imitations were of course far inferior to the original, and the attempt did not pay as a commercial speculation; but it answered Wedgwood's object, by showing what could be effected in English manufactures, when aided by high taste and liberal dealings.

Processes for Plain Earthenware.

In making all kinds of pottery or earthenware—from the coarsest brown pan to the finest China vase—clay is the main material employed, and a process of baking is that to which, after making, the article owes its durability. But beyond these points of similarity, the modes of proceeding differ greatly.

The clay employed for such purposes is in most instances combined with flint, which gives it firmness and consistency. The flints are brought to Staffordshire, from Gravesend and elsewhere, in irregular masses or nodules, just as they are taken from the ground. They are placed in a kiln shaped something like a lime-kiln, together with interposed layers of small coal; the coal is burned, and the flints are by the heat produced calcined to a white colour, and brought to a state by which they are easily broken. They are placed under a stamping or crushing machine (Fig. 1199), where a series of heavy hammers is so worked as to fall down in succession on the pieces of flint and crush them into small pieces. The flint is further ground in a mill (Fig. 1138), in which four arms work round large pieces of smooth stone, which grind the flint to an impalpable paste. The grinding-mill shown in Fig. 1201, as well as that in a former page, are other forms of apparatus adapted to the kind of material and the quantity operated on.

The clay, which is the other main ingredient, also requires some preparation before being mixed with the ground flint. One kind of clay from Cornwall, and another kind from Dorsetshire, are extensively used at the Staffordshire potteries: both kinds are brought thither in barrels, and both are worked up well to the state of a smooth paste.

Every large pottery has a mill-room, such as that in Fig. 1198, in which are contained a large number of cisterns, tanks, sieves, troughs, vessels, and other apparatus for effecting the perfect union of the flint and clay. Each of these is thoroughly worked up with water, and both are then mixed to the consistence of a very fine cream called "slip." The slip flows into an adjoining room, where it flows into a "slip-kiln:" this kiln is an oblong receptacle fifty or sixty feet long, six or eight wide, and from twelve to eighteen inches deep; it is formed of brick, and has a fire beneath, by which the "slip" is gradually deprived of a good deal of its moisture by evaporation, and assumes the form of stiff clay. This clay, although nearly homogeneous, is not quite so; and it is therefore made to pass through a mill by which it is brought to a uniform state. A similar effect is produced by kneading clay with the naked feet, a plan adopted in some branches of manufacture.

This, then, is the material; and we may next see how it is used. The "potter's wheel" (Fig. 1203) is a contrivance by which a small stand is made to rotate rapidly; and on this stand the potter puts the clay while forming into a vessel. In the English form of the arrangement, the wheel is turned by an attendant; in the Oriental form (Fig. 1209), as mentioned in a previous page, the potter is his own wheel-turner.

Suppose a cup or similar vessel is to be made. The potter takes a piece of the smooth prepared clay, large enough for the proposed purpose; places it on the flat bed or stand of the wheel; gives instructions to his attendant to rotate the wheel; and fashions the cup with his hands. By a dexterous use of the thumbs and fingers of both hands, pressing and pinching the clay in various ways, he speedily transforms the shapeless mass into a hollow cup, having both externally and internally the proper contour imparted to it. He is provided with small gauges and tools, by the aid of which he is enabled to ensure accuracy in the shaping of the vessel. The vessel is then removed from the lathe, and laid aside to dry; and another mass of clay taken to be treated in a similar manner. All kinds of plain circular vessels, such as cups, basins, &c., are made in this way; and it is surprising to observe how quickly the shape of the vessel is produced from the piece of clay.

As the fingers of the workman do not give perfect smoothness to the clay, most vessels require a process of "turning" when partially dry. This is effected at a lathe (Fig. 1207) much in the same way as any other kind of turning; and by this means rims, ledges, stands, &c. are given to the vessels. If the vessel be such as requires a handle, a tea-cup for instance, the affixing of this handle is one of the early processes. Plain handles for such vessels are made from long strips of clay; which strips receive their form by being forced through holes in a small brass mould or press—somewhat in the same way as maccaroni is made in Italy. A portion from one of these strips is cut off, sufficient in length for one handle; and the workman dexterously affixes this to the cup (Fig. 1202); bending it to the proper curve, and using a little of the liquid "slip" as glue or cement.

In making such an article as a plate or saucer, the shape is produced partly by the aid of a mould. There is first prepared a wooden model similar in form to the plate; and from this is cast a mould in plaster of Paris. The mould is placed upon the "throwing" or "potter's wheel;" and the potter, taking a piece of clay sufficient for the purpose, presses it to a flat circular form, and places it on the mould. By means of damp sponge and a few simple tools, and by the rotation of the stand on which he has placed the mould (Fig. 1204), he speedily imparts the form of a plate to the thin piece of clay. The plate is kept on the mould during a subsequent process of drying in a stove-room; and when removed from it, is trimmed and turned in the same way as any other vessel.

When the exact form is given to the article of earthenware, whatever it may be, preparations are made for "burning" or "firing" it; by which it loses its clay-like dampness and heaviness of appearance, and acquires a granular and stony texture. For the very commonest kinds of pottery very little more care is necessary than in the burning of tiles and such like articles; but for the neat earthenware of modern days, care is taken to prevent the smoke and flame of the kilns from acting directly on the ware. For this purpose the articles are put into oval receptacles or cases called "seggars" (Fig. 1206): these are made of a kind of fire-clay which will resist a very intense heat, and are so formed that several vessels can be placed in each without touching one another. The "biscuit-kiln," where these seggars with their contents are placed, is a circular building having a door or entrance, and flues ranged round its exterior wall. The seggars are taken into and built up around the kiln (Fig. 1205); the door is closed up air-tight; the fires are kindled beneath; and the whole are left for a space of thirty or forty hours. During this time the air in the kiln becomes highly heated from the fires, and the heat acts through the thickness of the seggars with so much force as to thoroughly bake the pieces of ware deposited within them.

At this stage of the proceedings the ware is about to receive the "glaze" or "glazing" which adds so much to its beauty; but as this is much the same in character whether for plain or for coloured earthenware, we will speak of the latter before proceeding further with the former.

Processes for Printed or Blue Earthenware.

Until the time of Wedgwood, scarcely any attempt was made to impart colour or ornament to vessels of earthenware. The costly specimens of gilded and painted porcelain were procured from abroad; while the coarse ware made at home was deemed undeserving of any attempt at adornment. The art of applying vitrifiable colours to the surface of earthenware, or of mixing them with the substance of the clay, was very little known in England at that time.

There is adopted at the present time, for common yellow ware, a process which may perhaps illustrate one of the rude stages in the progress of the decorative art. The articles so prepared are called "dipped ware," and have two, three, or four colours on the surface, somewhat raised above the general level, and exhibiting the form of rings, spots, curls, &c. These are produced in a curious way. The vessel is fixed to a lathe, with one of its sides uppermost, and made to rotate rapidly. A little clay is mixed with water to the consistence of cream, and coloured to any desired tint: this coloured clay is put into a funnel having a small hole at the bottom; and while the vessel is rotating, the workman dexterously allows the colour to flow out from the funnel, with just such a rapidity as shall enable him to form any required device in the vessel. He has the means of checking the flow of the colour at pleasure; and by that means he is enabled to vary his pattern. If two colours be used to produce the device, he makes use of a funnel having two compartments, and two small holes near each other at the bottom: the compartments are filled with liquid clay of two different colours; and by varying the mode of holding the funnel, he is enabled to produce a parti-coloured device without confounding the two colours together. He can even employ three colours in a funnel having three compartments; and all three are made to contribute toward the formation of a pattern which, though somewhat rude, presents a sort of attraction to buyers of humble taste.

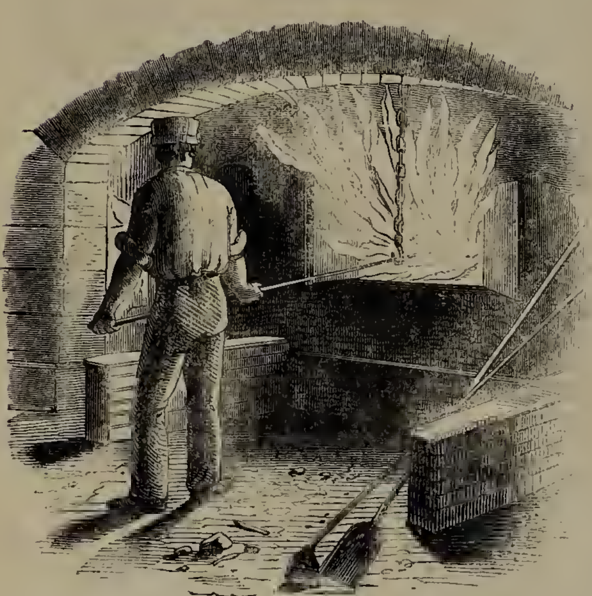
A kind of manufacture called "lustre-ware" receives an imitative golden appearance by a process involving something more of chemical arrangements. To produce this effect, certain metallic oxides are mixed up with essential oils to the consistence of a paint and applied with a brush to the surface of the vessel; and after this has been exposed to the heat of a kiln, the paint undergoes such a change as makes the metallic oxide exhibit a warm hue, something between that of gold and copper. No gold is employed in this process, but such a metal or mixture of metals is chosen as will give this hue when fired.

The *blue* patterns of earthenware are, however, those to which the advancement of this branch of art has been mainly owing. In the earlier stages of the manufacture after the commencement of the decorative attempts, one mode of proceeding was termed "blue-painting." This consisted in giving to the edge of the cup or vessel a simple border, by means of colours applied with a pencil: the vessel was placed on the top of a rotating stand; and the workman was able, with a steady hand, to guide the pencil round the edge of the vessel. Another mode of producing a blue pattern was by the use of perforated plates, in the manner of stencil-plates; the colour passing through the perforations, and thereby forming a definite pattern.

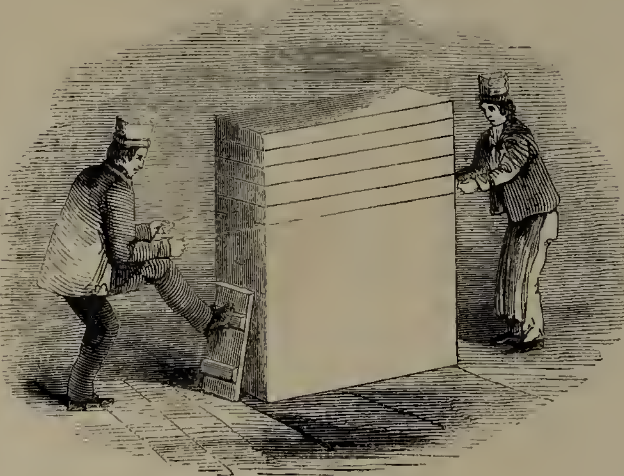
The production of a blue pattern by means of printing is, however, the most remarkable and the most important. In the first place a pattern is drawn upon paper, suitable in size and shape for the vessel which is to be decorated. In past times the devices chosen were very unmeaning, and in poor taste; but there has been a gradual improvement since, and many pleasing patterns are occasionally seen, though bad ones are far more numerous than could be wished. The design is given to an engraver, who engraves it on a flat copper-plate, just in the same manner as for other specimens of that art. Meanwhile thin paper of a very peculiar kind is manufactured, expressly for the use of the potter; it is thin, but very tough, and in other ways fitted for the particular service which it is to render. The plate is heated on a stove, and ink or paint is rubbed over it (Fig. 1208): the paint being about the consistency of printers' ink, and of such a kind as will present a blue colour after baking. When the plate has been rubbed quite clean, except in the sunken lines which have received the colour, a piece of the prepared paper, moistened with soap and water, is laid upon it, and the two are passed through a small rolling-press. The printed paper is immediately afterwards taken up by a female, who cuts it to the required shape for the vessel, and lays it on in its proper place (Fig. 1212) so as to make it adhere well to the surface of the ware. The ware has been baked but not glazed, and the paint on the paper has just sufficient dampness to be transferred from thence to the ware. To aid this transfer, the woman rubs the paper very forcibly with a pad of flannel wrapped round the end of a stick. When this is done, the vessel is soaked in cold water, by which the paper is softened and easily removed in fragments, leaving behind it the pattern impressed on the ware by the paint transferred from the paper. A separate impression from the plate is thus required for each vessel: the paper being destroyed in the act of removal from the ware. The paint presents a brownish colour as thus produced, but it changes to blue by the subsequent heat of a kiln. By a change of the materials of which the paint is made, green or any other colour may be produced instead of blue.

1213.—Soap-boiling Coppers.

1217.—Tank for crystallizing Alum.



1214.—Making Red-lead.

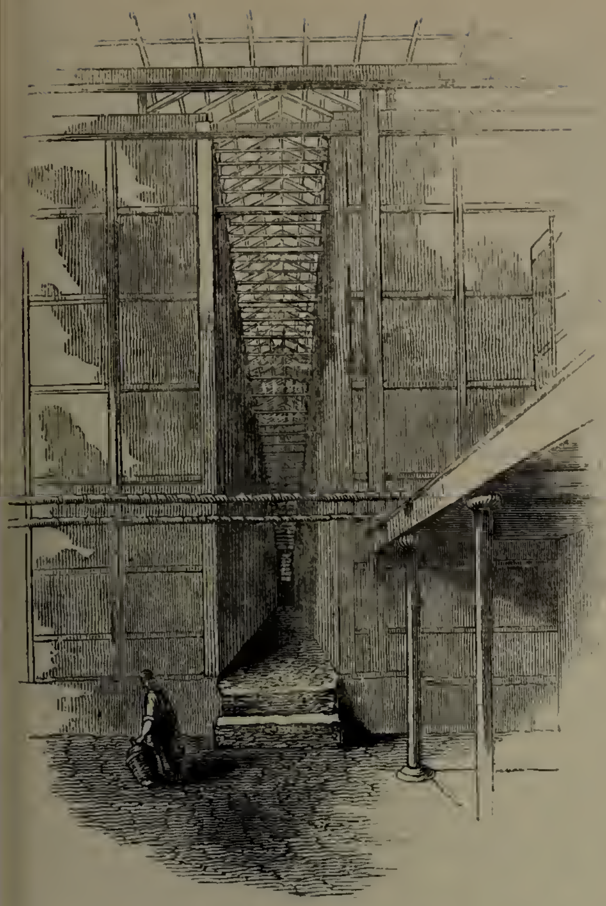


1215.—Cutting Soap.

1218.—Cylindrical Mass of crystallized Alum.

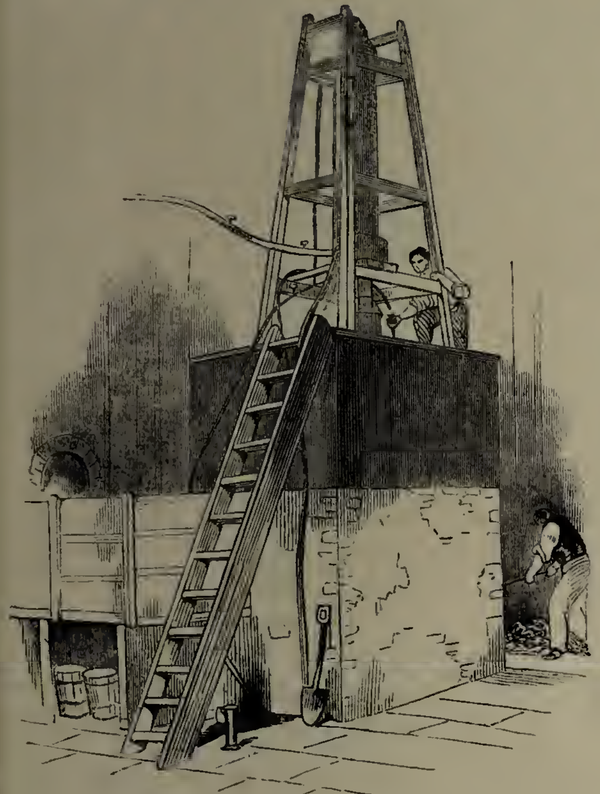
1216.—Interior of an Alum-mine.

1219.—Filling Soap-frames.



1220.—Sulphuric-acid Chambers.

1222.—Alum Sprin at Hackfall, Yorkshire.



1221.—Platinum Still, for Sulphuric Acid.

1223.—Setting the Beds for White-lead.

1224.—White-lead Manufacture.

The Materials and Making of Porcelain.

The semi-transparent material, *porcelain*, is still regarded, as it has been ever since it was known, as the highest and choicest variety of this manufacture; and it need not excite surprise that attempts should be made in Europe to imitate the productions of China.

A curious circumstance led to the establishment of the porcelain manufacture in Saxony. A German alchemist, named Botticher, while searching for the "philosopher's stone," which has driven so many ingenious but mistaken men out of their wits, prepared some crucibles, which, by the repeated action of heat, assumed very much the appearance of porcelain. He had the wisdom immediately to abandon his alchemy, and to establish a manufacture of porcelain, which in the end became very advantageous both to himself and to his country. The processes were carried on at Dresden with much secrecy; and there resulted in time a very fine collection of porcelain in that city, which was placed in the royal palace as companions to pieces of porcelain brought from China. Jonas Hanway, who visited Dresden in 1753, thus speaks of this double collection:—"The vaults of this palace consist of fourteen apartments, filled with Chinese and Dresden porcelain. One would imagine there was sufficient to stock a whole country; and yet they say, with an air of importance, that a hundred thousand pieces more are wanted to complete the intention of furnishing this single palace. Here are a great number of porcelain figures of wolves, bears, leopards, &c., some of them as big as the life, a prodigious variety of birds, and a curious collection of different flowers. A clock is preparing for the gallery, whose bells are to be also of porcelain: I heard one of them proved, and think they are sufficient to form any music; but the hammers must be of wood. Here are forty-eight large China vases, which appear to be of no use, nor any way extraordinary, except for their great size; and yet his Polish Majesty purchased them of the late King of Prussia at the price of a whole regiment of dragoons,"—a singular sort of purchase merely for Chinese vases. One part of this Dresden collection consisted of a series of specimens, in orderly arrangement, from the first rude result of Botticher's labours to the most finished production of the most practised artists.

After the Jesuit D'Entrecolles sent information to Europe concerning the materials employed by the Chinese in making their porcelain, Réaumur and other ingenious men in France made investigations to discover whether any similar materials could be found in that country. Réaumur communicated to the Academy of Sciences, about the year 1727, an account of his researches. He examined Chinese and Dresden specimens, and compared them with the best that France could produce: he broke them, burnt them, analyzed them, and tested them in various ways; he procured specimens of the two kinds of earth used by the Chinese, the *kaolin* and the *petuntse*, and tried them separately and together, by the heat of a furnace; he decided on what peculiar properties each kind derived its value; and in a short time afterwards it was discovered that there were in France varieties of clay or earth which, if not identical with those of China, approached sufficiently near to answer the same object. A manufacture was established under royal patronage at Sèvres; and at this place specimens of porcelain were produced which still rank among the finest known.

With respect to our own country, it was not till about the year 1768 that similar ingredients were found to be within the reach of English potters. Mr. Cookworthy in that year discovered certain mineral substances in Cornwall, similar in their properties to the porcelain earths of China. He procured a patent for the use of these materials in this way, and succeeded in producing very good specimens of porcelain; but Wedgwood happened to have commanded attention about that period by the excellence of his cheaper wares, and Cookworthy did not derive any great profit from the discovery. The seed was, however, sown, and led to the establishment of the porcelain manufacture in this country on a firm footing. It is now carried on at most of the pottery towns in Staffordshire, at Derby, at Worcester, and near Rotherham.

In the present mode of manufacturing English porcelain, the processes adopted are nearly the same as those before described in relation to common earthenware, but more carefully conducted. The materials consist of common flint, flint in the calcined state, Cornish stone, Cornish clay, and calcined bone, all brought to the state of a very fine powder before being mixed together. The clay gives a yielding or plastic nature to the mass, the flint gives a vitreous quality, and the calcined bone aids in giving the translucency for which porcelain is so much admired. The materials are crushed and ground, then mixed, then worked up with water to the consistence of cream, then evaporated in the "slip-kiln" to the state of a soft clay, and then kneaded to a smooth and uniform state.

The formation of vessels at the "potter's-wheel," or "throwing-wheel," is the same for porcelain as for earthenware. Not only vessels, such as we usually understand by the term, are thus made, but various other articles whose shape is in the main circular. Within the last few years a fashion has arisen of making porcelain candlesticks, taper-stands, fancy-baskets, door-handles, and numerous other articles, whose shape is first given by the throwing-wheel, and then finished by the lathe and by hand-worked tools. The turning, the making of plates and flat dishes by pressure, the mode of making and fixing handles—all are the same for porcelain as for earthenware.

Where a porcelain vessel presents an ornamental form, something more is required than throwing, pressing, and turning: it requires *casting* in a mould. For this purpose a drawing is first made, the exact size and form of the proposed vessel; and from this drawing a modeller prepares a model in a smooth kind of clay, which he works up with a few simple tools until it presents an exact counterpart of the vessel. If the pattern or shape be comparatively simple, a single mould is made from this model, and the vessel is made by pressing the porcelain clay into it; but if it be more complex a double mould is necessary, and the clay is poured into the vacuity between the two moulds in a liquid state. The moulds are made of plaster of Paris. A casing of clay is first formed around the model, at a small distance from it, and the cell thus made is filled up with liquid plaster of Paris; the plaster soon solidifies, and the mould can be then readily separated from the model. The porcelain clay, of which the vessels are made, is either pressed into the mould in the way just alluded to, or it is mixed with water to the state of a thick cream, and poured into the mould, where the plaster speedily absorbs so much of the water from the clay as to allow the latter to solidify pretty quickly.

The vessels, when made by any of these processes, are placed in "seggars," or cases, and the cases placed in a "biscuit-kiln," where they are baked to the state called "biscuit." This biscuit presents a peculiarly soft, white, and delicate appearance, and is much lighter than the unbaked clay.

The "glazing" of porcelain will serve to represent that of all kinds of earthenware. It has been stated that some of the earlier improvements in the manufacture consisted in the discovery of the use of salt in the process of glazing; and since that time many other improvements have been made in the same direction. It is rather an unfortunate circumstance that *lead* has become one of the ingredients frequently employed, for this metal is very deleterious to the workmen using it. Any of the substances which make glass will make a glazing for earthenware; for this glazing is nothing more or less than a thin film of glass, intended partly to prevent the porous quality of the ware from absorbing moisture, and partly for the preservation and adornment of the vessels. Oxides of metals, alkalis, and flint, are the chief substances employed: these give rise among themselves to many different combinations, and almost every manufacturer has a recipe of his own.

The glaze is brought to a liquid state, and appears as a whitish creamy liquor. It is contained in wooden troughs or tubs, conveniently placed near the kiln where the ware is to be heated after the glazing. Each article is taken up separately, held lightly between the fingers and thumb, and dipped into the glaze; by a dexterous turning of the article, the workman so manages as to make all or nearly all of the superfluous liquid flow from it, so as not to settle in drops. The vessels, one by one, as they are dipped, are placed on a board, and are afterwards laid in seggars, with small bits of porcelain between them to prevent their touching. The seggars are piled up in a "glaze-kiln," which is formed something like the "biscuit-kilns," and heated in the same way; the heat required to vitrify the glaze is much less intense than that for baking the ware, and is continued for a smaller number of hours. Great caution is needed in preventing the access of smoke or any other cause of discoloration to the ware; for if this combines with the glaze, it becomes a permanent disfigurement.

Painting and Gilding of Porcelain.

The highest kind of art employed upon porcelain is the *painting* which it sometimes receives from the pencil of one who is, or ought to be, an artist in the better sense of the word. Great advancement has been made in this employment within the last few years; since manufacturers now find it to be their interest to employ men of cultivated taste in this avocation. The "School of Design" is at the present time paying much attention to this subject; and there are even arrangements making for teaching this art to females, as a very fitting one to be added to the slender list open to them in this country. The porcelain manufacturers of Staffordshire and of Worcester now pride themselves on the beauty of the designs produced by them on porcelain; and it is a worthy object of solicitude to give to the articles produced the same degree of excellence in regard to taste as in the durability of the ware manufactured.

The Chinese painters of porcelain are more successful in the brilliancy of their colours than in the taste of their patterns. The arts of design are not, in any of their branches, in a very palmy state in China; and the odd conceits depicted on their porcelain certainly convey no very high idea of artistic skill. Mr. Porter remarks:—"In examining the painted porcelain of this singular people, one is almost led to imagine that their artists have been debarred the sight of the objects which they attempt to represent, as otherwise some among them must surely have possessed sufficient innate taste to have led them from the general track, and instead of the miserable caricatures that disgrace their labours, to have made some approach towards the truth in his delineation of natural objects. . . . . One artist forms only coloured circles about the edges; another traces flowers, which a third paints; a fourth delineates nothing but mountains; a fifth describes water; a sixth traces the outline of birds, which a seventh fills up with colours. Other artists trace and colour animals; others again perform the same tasks with the human figure; and in this way every object of art and nature found upon their porcelain is the work of a particular artist, who does not attempt the delineation of any other subject. To this system, so useful in conducting every merely mechanical operation, may possibly be owing the continued adherence to old and faulty methods. The celerity which it is calculated to produce is unfriendly to the improvements suggested by genius; and if ever one artist among the crowd should be found with taste enough to aim at forming and embodying juster conceptions, his approaches to nature would only serve to render more glaring the deformities produced by his fellow-labourers, and would therefore be wholly inadmissible."

Besides the usual process of painting and gilding, the Chinese adopt curious methods of producing ornamental porcelain. One is a sort of magic porcelain, in which the colours and devices appear only when the vessel is full of water. In making these, the first requisite is that the vessel shall be extremely thin. After the baking, the figures are painted on the inside; and when this painting is dry, a very thin coating is laid over it, formed of the same material of which the vessel was made, in a semi-liquid form, and a coating of varnish is applied over this. The picture is thus buried as it were between two layers of porcelain. The outside of the vessel is then ground down as close to the figures as possible, and then varnished. The vessel, thus prepared, is placed in an oven, and all the layers baked together. The colours chosen are of a very faint tint, so as to be scarcely if at all visible in the present state; but when the vessel is filled with water, the coloured device becomes visible, from a difference in the play of light in and around the vessel. Another peculiar kind of porcelain made by this singular people presents the appearance of having a raised device, although the surface is quite smooth. To produce this a very thin and fine porcelain cup is made in the usual way, and well smoothed inside and out; but before it is baked, and while the clay is yet damp, a stamp cut in relief is pressed upon the inner surface of the cup. Very fine white varnish is next applied copiously over both surfaces, so as to fill up the cavities where the impression was produced by the die. By this means both surfaces are rendered smooth and regular again; but on holding up the cup before a light, the device will appear with much effect, since the parts where there is a great thickness of varnish and a small thickness of porcelain will present a different tint from those parts where the opposite conditions occur.

The painting of porcelain, as carried on in England at the present day, is managed in the following manner. The colours employed are much the same as those used in enamel-painting and in glass-staining, viz., principally oxides and salts of metals. Oxide of tin; nitro-muriate of gold; muriate of tin; oxide of gold; oxides of iron, of antimony, of cobalt, of zinc, of copper—all are used, and many others in addition. These are ground to the greatest possible degree of fineness, and are then mixed up with fine pure oils, and with spirit of turpentine, to the state of a paste. The porcelain-painter sits at a bench or table, with a palette before him on which the prepared colours are spread; he is provided with camel-hair pencils and with brushes of small size, and conducts his operations very much in the same manner as a miniature-painter. Although the subdivision is not carried out in the same way as in China, yet each artist confines himself pretty much to one kind of device, according as his talent and taste lead him to flowers, to foliage, to animals, to landscape, to figures, or to fanciful ornament. The painter holds the piece of porcelain in a convenient position, and paints the device; if a circular coloured band or ring is to go round the vessel, he places it on a stand which may be made to rotate while his pencil is marking it. The brilliant gold which most specimens of porcelain present is laid on just in the same way as colours; the gold is ground up with oil and turpentine to the consistence of an olive-coloured paint, which is laid on with a pencil; and by the subsequent processes of firing and burnishing, the gold resumes its natural colour and lustre.

When the porcelain is painted, it is placed in a small arched oven called an "enamel-kiln," where it is exposed to a heat just sufficient to make the colours vitrify and combine permanently with the porcelain. A very high degree of care and delicacy is required in the management of this kiln as to temperature and

duration of the firing: the painter often requires to watch the progress of the operation two or three times by taking the porcelain from the kiln and examining the state of the colours. The painting and the glazing are managed conjointly in different ways, according to the kind of effect required to be produced on the porcelain: sometimes the colours are applied when the porcelain is in the state of "biscuit," and at other times after a glazing has been given to it. When the ware is glazed after the painting, a good deal of care is required in applying heat to it, to prevent injury to the colours.

THE MANUFACTURE OF CHEMICAL MATERIALS.

As the class of materials which formed the first portion of the subject of this chapter were the harder kinds of mineral produce, such as gems, marble, and stone; and as the next class comprised those which are in a soft and pliant state when wetted; so may we now glance at a third class, in which the substance produced in almost every instance assumes a liquid form at some stage or other of manufacturing processes. Whether it be the common salt or the common soap which are so useful to us; or the alums, or alkalis, or acids which are so largely used in the arts; or the gums, resins, and other vegetable products which are exuded by so many varieties of plants—all, with but few exceptions, go through different phases of the liquid and solid forms, and all may conveniently come under the designation of "chemicals."

The manufactures connected with the preparation of these substances require rather nicety than complexity of arrangements, and belong quite as much to chemistry as to manufactures. A few examples will suffice to convey an idea of the whole series. Let us commence with

Soap and its Ingredients.

All the varieties of soap, however different they may be one from another in colour and consistency, are composed of some kind of oil or tallow with some kind of alkali; the choice of ingredients being very wide; and certain qualities being imparted to the soap by the addition of other substances. "Mottled soap" is made from tallow, "kitchen-stuff," soda, a little salt, and water; "white soap" is made from the best tallow, without the addition of any ingredient which will injure the colour; "yellow soap" is made from tallow, palm-oil, soda, and resin; "soft soap" is made from tallow, whale-oil, and potash; while the large variety of "fancy soaps" are made from white soap perfumed with various ingredients.

The tallow for soap is brought principally from Russia, where it is prepared from the fat of a breed of oxen whose flesh is very little suited for the purposes of food. Palm-oil is obtained in Africa by bruising the fleshy part of the fruit of the oil-palm tree: it is liquid in the climate whence it is obtained, but assumes the solid form in our climate. The other oils employed for soap are obtained either from fish or from plants, in a way which has before engaged a little of our attention; and in respect to the oil from seeds a little further detail will be given in connexion with the subject of linseed-oil.

The alkalis used in soap-making are potash and soda: the former (at the present day) obtained chiefly from America, and the latter in our own country. The colonists of Upper Canada bring the forest-trees to useful account by burning them and obtaining potash from the ashes. The elm is found to be the best tree for this purpose; next to this the ash, the beech, the black birch, and the maple. The mode of proceeding is described by an eye-witness to be as follows:—The trees are cut into logs, heaped up in a pile, and set on fire: all the inflammable components of the wood burn away, but an ash remains which contains potash. As a means of extracting this potash, the ashes are collected, and put into several large rudely-formed tubs erected usually in a sort of encampment in the forest itself. Water is poured upon the ashes, and allowed to act upon them for several days; during which time, the alkali or potash becomes separated from the ashes and dissolved in the water. The next stage in the process is so to evaporate this potash lye as to procure the dry potash or "black salts" from it. The lye is allowed to flow out from the tubs into large iron caldrons, where it is boiled for a considerable period. When it has attained a semi-solid state, the lye is set aside to cool, and assumes a crystallized appearance when cold. This constitutes the "black salts" of Canada: it is a rude sort of carbonate of potash, and requires a good deal of purifying before it is fitted for use in making soap.

The alkali used in making soap is more frequently soda than potash. This alkali has undergone a good deal of change in the mode by which it is procured. Formerly it was procured from Spain and Italy, where it was made by burning the ashes of a plant called the *salsola soda*. Another and less expensive source for the soda was the ashes obtained by burning the sea-weed which, under the name of *kelp*, is found so abundantly on the northern shores of Scotland. At one time this manufacture gave employment to a large number of persons in the Orkneys and other parts of the north; but recent chemical discoveries have almost destroyed the demand for kelp, so that the kelp-burners have suffered much adversity. A similar manufacture is carried on in America. In the 'Narrative of the Surveying Voyages of the Adventure and Beagle,' it is said that "when a sufficient quantity of kelp has been collected, it is spread out in a place where it will be dried by the sun and wind, and when dry enough to burn, a hollow is dug in the ground three or four feet wide; round its margin are laid stones, on which the weed is placed and set on fire; quantities of this fuel being continually heaped upon the circle, there is in the centre a constant flame, from which a liquid substance like melted metal drops into the hollow beneath. This substance is raked or stirred with iron rakes, and brought to a uniform consistence while in a state of fusion; and when cool, it consolidates into a heavy, dark-coloured alkaline substance."

In the making of soap from the ingredients just described, a series of purifying processes is necessary. When the tallow and the alkali are properly prepared, they are mixed together with the other ingredients in large boilers or coppers (Fig. 1213), where they are exposed to a heat sufficient to melt them, and to make them thoroughly incorporate into liquid soap. When this has taken place, the soap is drawn off into buckets or pails, and emptied into the "soap-frames" (Fig. 1219). These are large upright receptacles, which allow the soap to solidify into a mass weighing three or four thousand pounds. When this solidification has taken place, the frame is removed piecemeal, leaving the mass of soap standing on its edges. To cut up this mass into the bars or cakes in which soap is usually sold, two men cut it into parallel horizontal layers about three inches thick, by means of a wire held by two handles (Fig. 1215): and these layers are afterwards cut into oblong bars by similar divisions in a vertical direction.

All the various kinds of hard soap are made nearly in this way, with slight modifications of the process according to the quality of the material. Soft soap, being always in a pasty state when made, does not require these processes of moulding and cutting: it is poured into casks or barrels, and in that state sold.

Salt and Alum.

Salt, one of the most valuable of natural products, is so far plentiful as to be procurable at a very cheap rate. It is contained in every variety of sea-water; in beds or layers which are believed to have been once at the bottom of a salt-water lake; and in brine which is formed by springs of water happening to flow over these beds. The processes by which the salt is brought into the state familiar to us differ a little in these several instances, and may be illustrated by a few examples taken from different countries.

In Sicily are the salt-springs depicted in Fig. 1225. Rock-salt is found in some parts of the island, where it can be dug with the axe and shovel in the same manner as earth; while in other parts are springs of brine, which flow up to the surface of the ground, and are there made to evaporate in shallow circular receptacles by the heat of the sun.

Another woodcut (Fig. 1230) represents a "salt-pan" in the Forth, which will illustrate a somewhat more perfect mode of obtaining salt by the evaporation of sea-water. There is a very large cistern, which is filled with sea-water by means of a pump worked by a water-wheel or other machinery. The water is drawn from a considerable depth below the surface, as containing a larger amount of salt dissolved in it. After settling in the cistern, so as to deposit a good deal of its sand and mud, the sea-water is allowed to flow slowly into the "pan:" this pan is a large iron vessel, sometimes lined on the inside with lead. A strong fire is kindled beneath the pan; and as soon as the water becomes warm, it is clarified by the addition of bullock's blood, or some other ingredient, and also skimmed. It is made to boil for four hours, at the expiration of which time crystals of salt begin to appear at the surface. More water is added, more heat applied, and the same process repeated three or four times over, until the pan contains a considerable quantity of crystals. The crystals are removed to other vessels, where the moisture is allowed to drain away from them, and they are then quite ready for use, the salt so procured being very pure. Of the persons employed at the Forth salt-works near Edinburgh, it is said that they "are a very peculiar race. In appearance and manners they are not unlike colliers; whom too they resemble in another point, their former state of slavery. Till within the last fifty years or so, the salters were transferred with the works on any change of property, in as positive a manner as the black population in our own colonies prior to the late changes, or as the American slaves at this moment. Their freedom was obtained by an application of the proprietors themselves, a rare and honourable action; but so little did the salters themselves appreciate it, that they exclaimed against the whole affair as nothing more than a petty attempt on the part of the proprietors to relieve themselves of a trifling burden to which they were liable on the marriage of a salter or coalman!"

In Hungary there is a considerable supply of salt in the form of a hard rocky bed or vein, which requires the aid of a pickaxe for its extrication. The salt, when procured, is royal property, and is sold under very stringent regulations. In Tuscany the same principle is acted on: all the salt found in the country being deemed the property of the government. Captain Basil Hall gives a curious example of the absurd extent to which the restriction is carried. One of the inhabitants of Tuscany said to him:—"Not only are the ordinary steps taken to prevent the intrusion of competitors in the open market, but such is the dread of a rival manufacture, it is actually against law to draw a bucket of water, so that when my children were once directed to be washed in salt water, I was obliged to apply for a regular commission from the custom-house before my servant would venture to bring a couple of gallons from the shore. One summer's day, when my sons were bathing on a shallow part of the coast, they observed a thin but extensive coating of salt on the surface of the sand, caused, no doubt, by the sun's rays having evaporated the water. The boys wondered that so valuable an article, as they had been taught to consider salt, should be left on the beach to melt in the rain, or to be washed back again into the surf. Thinking no evil, of course, they collected a towel full and brought it to me, who was as much surprised as the lads. But while we were standing around the newly discovered treasure, and speculating on the strange fact of its being allowed to run to waste, one of the Italian servants, who happened to be passing, saw the contents of the towel. Turning as white as the salt itself, he exclaimed—'In the name of the Virgin, how could you be so imprudent as to pick up salt from the sea-shore? Don't you know that you are subject to a heavy fine for infringing the laws of the country? Even now,' continued the greatly alarmed domestic, 'it is my duty to give information to government; otherwise, if it becomes known, I shall be punished.' The salt was, by general consent, buried in a hole in the garden, as a means of avoiding troublesome consequences."

In India the manufacture of salt is an extensive and very important feature. The salt is obtained by evaporation from brine-springs; and the sale of it is conducted under a regular system laid down by the British government.

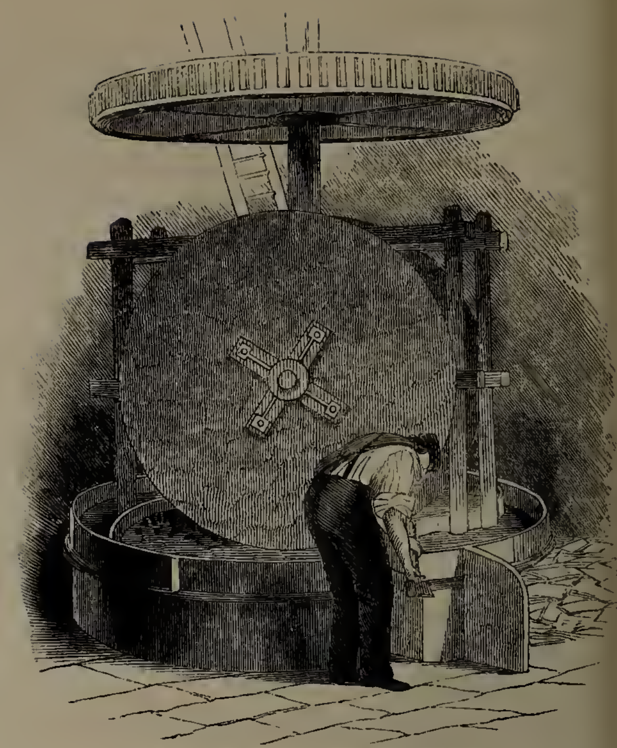
The particular mode adopted in the evaporation or preparation of salt depends a good deal on the prevailing climate of the country. In a hot climate, for instance, such as India, sea-water is enclosed in shallow receptacles, and there allowed to be acted on by the heat of the sun until much of the clear water has evaporated, and a crust of salt three or four inches thick has formed. This crust is broken up, and is placed in a covered place where all that can drain from it has an opportunity of doing so. The salt so obtained is called "bay-salt." In countries where a less elevated temperature is common, the evaporation of the brine requires to be effected by artificial heat instead of the heat of the sun; and the arrangements are then more or less similar to those of Scotland, lately alluded to. Such a plan is followed extensively in Cheshire, and also to a large extent in America, where the brine-springs are called "salt-licks." When a spring of water filters through the salt-beds of Cheshire, it becomes so saturated with salt as to form brine, and is then treated in the way here spoken of; but when the beds of hard rock-salt are untouched by subterranean springs, they are worked by the pick and shovel, and the salt so obtained is dissolved in brine previous to the evaporation of the latter, in order to strengthen it, and to increase the product.

Alum, a substance which bears some resemblance to salt in its crystalline appearance, is, like it, obtained by evaporation and other processes from solid materials existing in the ground, and also by an artificial combination of other substances. Salt is chemically a "chloride of sodium;" alum is a "sulphate of alumina and potash."

Many rocky strata have interposed between and among them the ore which customarily yields alum; and if a spring percolates through these strata, it imbibes the alum just in the same way as the springs absorb salt by passing through the salt-beds. Thus, there are extensive stores of alum in some of the strata of Yorkshire, near Whitby; and the water of certain springs which flow through these strata becomes so impregnated with alum as to form the "Alum Springs" at Hackfall in the same county (Fig. 1222). In some parts of the world alum is found pure in the crystallized form, ready for use; but most frequently it is obtained from one or other of three kinds of earth, designated "alum-stone," "alum-slate," and "slate-clay."

The mode of obtaining and preparing the alum at the Hurlet Alum-mine near Glasgow (Fig. 1216) will illustrate the general nature of the operation. This mine is an exhausted coal-mine; and the alum-ore is found coating the sides of the excavated galleries and

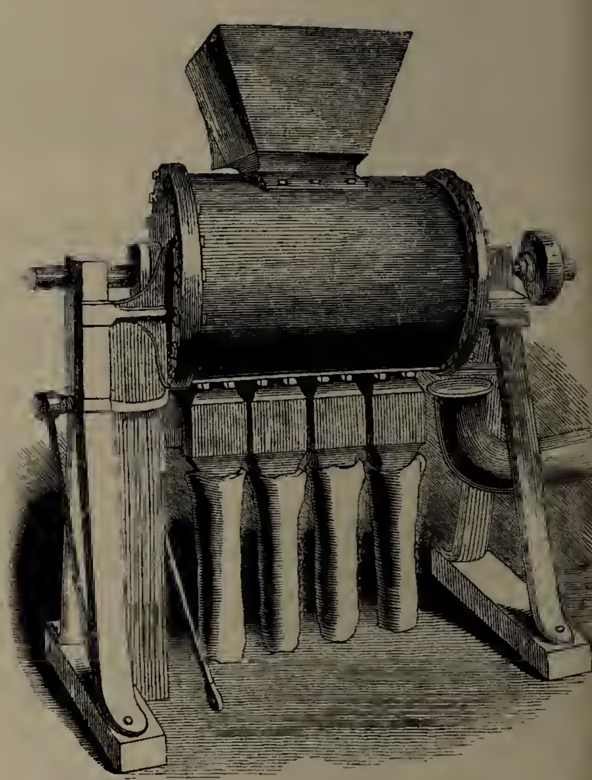
1225.—Salt-springs in Sicily.



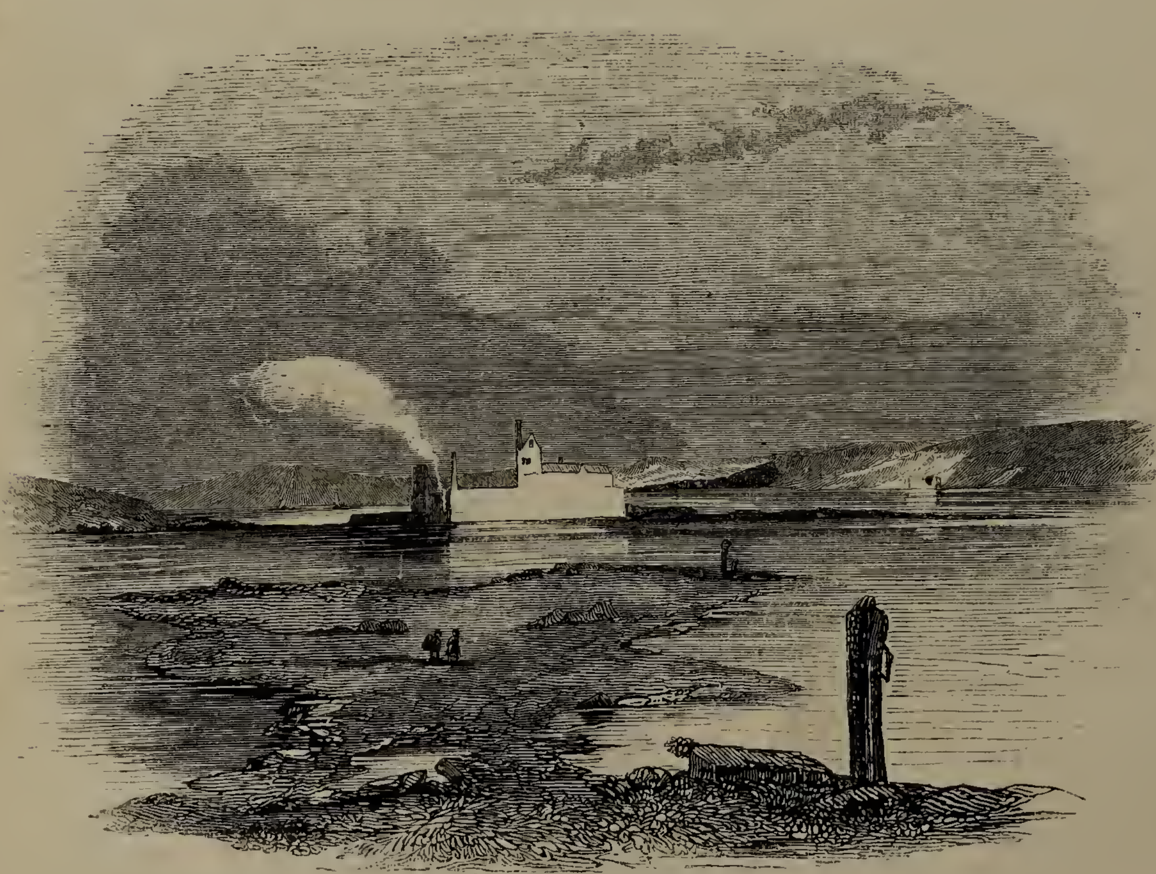
1226.—Grinding Linseed for making Oil.

1227.—Stripping the Bag from the Oil-cake.

1228.—Bags of Linseed in the Hydraulic Press.

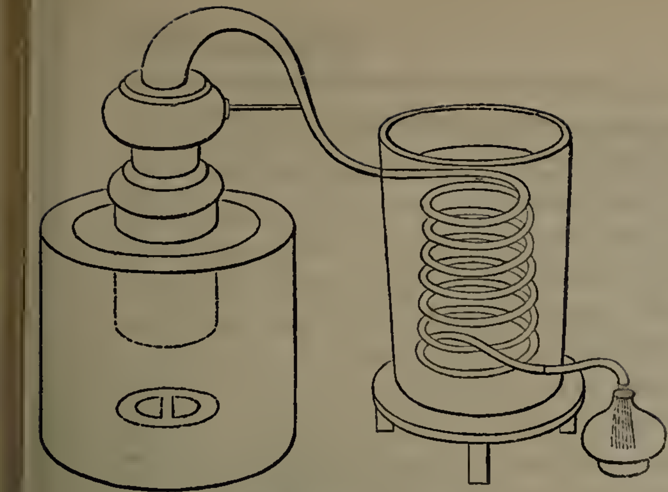


1229.—Crushed Linseed falling into Bags.



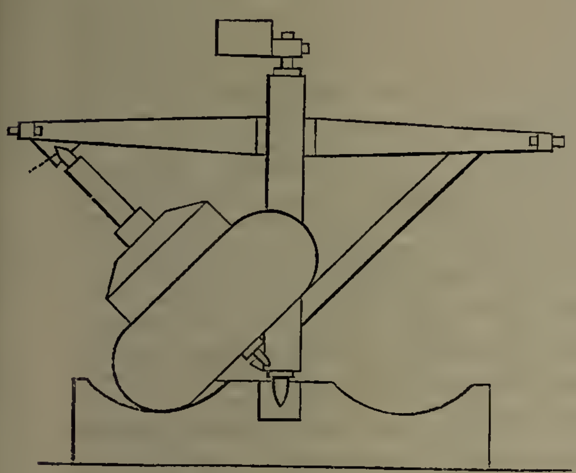
1230.—A Salt-pan on the Forth.

1231.—Trees producing Caoutchouc.

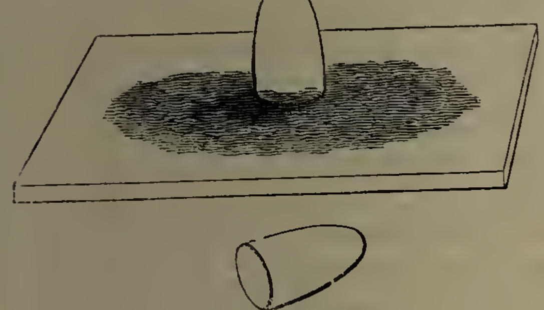


1235.—Chemical Apparatus.

1232.—Tar-making in Russia.



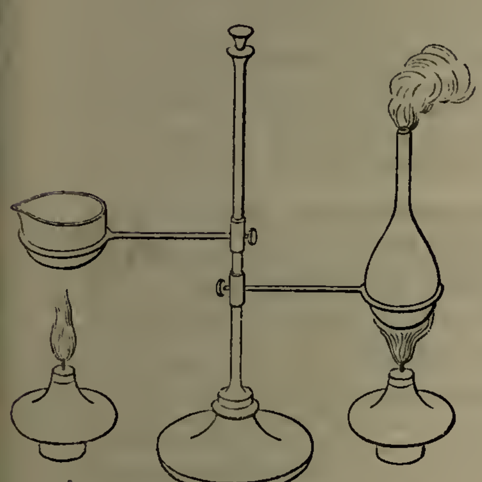
1236.—Chemical Apparatus.



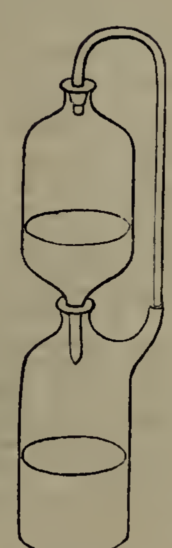
1237.—Chemical Apparatus.

1238.—Chemical Apparatus.

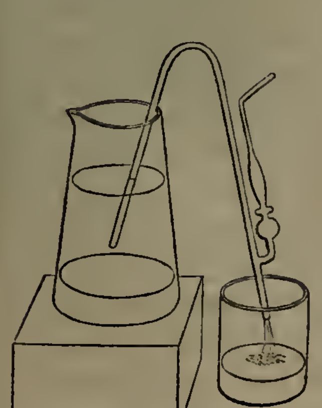
1233.—Soda-crystallizing Pans.



1239.—Chemical Apparatus.



1240.—Chemical Apparatus.



1241.—Chemical Apparatus.

1242.—Chemical Apparatus.

1234.—Soda-Furnaces.

passages. Originally there had been a stratum of this ore between a stratum of coal and a bed of lime; and the extraction of the coal having laid the ore bare, the action of the atmosphere had so far decomposed it as to exhibit indications of the crystalline form of alum, mixed up with other substances in the ore. That portion of the ore which has not been so much exposed to and acted on by the atmosphere, is in a stony state, and requires the aid of the pickaxe. The miners dig and collect the ore, and convey it in barrows to a vertical shaft or opening, where it is drawn up to the surface of the ground, in the same manner as coal at the collieries. The miners have bits of lighted candle stuck in their caps, and present a curious picture, as seen by the flickering gleam from these lights.

The rocky ore, when brought to the surface, requires more preparation than the crumbled ore. It is a slate-like substance, containing sulphur, iron, and alumina. It is broken into small pieces, built up into a long ridge or heap, and kindled by the aid of small coal: the calcining thus effected aids in the subsequent processes. The burnt ore, as well as the crumbled ore obtained from the mine, is steeped for several hours in water in large open receptacles (Fig. 1211), until the sulphates have dissolved in the water and the earthy residues have settled. The ore is steeped over and over again in the same way, until all its sulphates are obtained. The liquor is pumped into boilers (Fig. 1210), where a good deal of it is evaporated; and the remaining or concentrated liquor is transferred to large open coolers, where it remains about a fortnight. During this time the sulphate of iron crystallizes, and these crystals, when removed, form "copperas." The remaining liquor, which is sulphate of alumina, is boiled, and potash is added to it. On a further cooling, new crystals gradually form; and these crystals are the alum, or "sulphate of alumina and potash," which is the object of the whole process. The alum crystallizes in large square vessels (Fig. 1217), from whence it is dug and removed.

A mode is adopted in some of the chemical works of forming alum artificially, from the three substances which compose it, viz. sulphuric acid, alumina or pure clay, and potash. In the first place, fine Cornish clay is pounded to powder, calcined in an oven, and mixed with sulphuric acid in a pit or appropriate vessel. When these two have combined chemically (which they do with a rapid commotion like boiling), water is added to them, and the mixture is allowed to remain quiet, for the settlement of any other particles which may be set free. The liquor is pumped into a leaden vessel, where sulphate of potash is added to it; and the whole is transferred to another vessel to cool and crystallize. The different materials combine so as to form a "sulphate of alumina and potash;" but as the alum thus formed is rather crude and impure, it undergoes the process of "roaching:" this consists in dissolving the alum by means of steam, and again crystallizing it in tall cylindrical vessels. When the crystallization is finished, the sides of the vessel are taken away piecemeal (Fig. 1218); and the alum is presented to view as a beautiful cylindrical mass, having almost a glassy smoothness and transparency.

Red-Lead and White-Lead: Colour Manufactures.

An important class of chemical manufactures relate to the production or preparation of colours, whether for the house-painter or the artist, for the makers of floor-cloth or of paper-hangings. In most instances these colours are made from oxides of some of the metals; in others they result from metallic salts, from earthen substances, or from exudations from trees. Red-lead and white-lead will illustrate very conveniently two among the many modes of bringing metals to bear upon the production of colouring substances.

Red-lead is an oxide of the metal, formed by causing the oxygen of the air to combine at a high temperature with metallic lead in a liquid state. A reverberating furnace, with an arched roof, is employed for this purpose. Pigs of lead, to the extent of about a ton and a half in weight, are thrown into the furnace, and there exposed to flame and heat which act directly on the surface. As soon as the lead becomes melted, a man opens the door of the furnace, and keeps the molten lead constantly stirred by means of a long rake held in his hand (Fig. 1214). For five or six hours this stirring is continued, until every part of the mass of lead has been in turn exposed to the action of the air which enters at the opened mouth of the furnace. The effect of this is curious: the lead loses its metallic appearance and its fluidity, and assumes the appearance of a greyish yellow powder. This powder consists of "protoxide of lead" mixed with small particles of metallic lead which have not yet been acted upon in the proper way. To separate these small particles, the powder is ground in a mill till the lead is thoroughly crushed; and on being steeped in a vessel of water the yellow protoxide dissolves in and becomes mixed up with the water, while the lead falls to the bottom. The water is conveyed to other vessels, where the yellow powder settles; and on this being collected and dried it forms "massicot." To convert this "massicot" into "minium" or "red-lead," it is again exposed to the action of heat in a reverberating furnace; and by the gradual absorption of more oxygen, it changes its colour from yellow to red, its chemical nature from a "protoxide" to a "deutoxide" of lead, and its commercial name from "massicot" to "red-lead."

White-lead is produced in a way perhaps more remarkable than red-lead, and requires somewhat more extensive manufacturing arrangements. It is a carbonate of the metal; but is not produced by the immediate union of lead with carbonic acid.

The first stage in the manufacture is the preparation of thin pieces of lead, which shall present a considerable surface in proportion to their thickness. The casting of these pieces, as well as almost all the stages in the subsequent processes, are conducted in most of the white-lead works in the north of England by women—a singular anomaly, for which it does not seem easy to assign a reason. There is a small square furnace, built up in the middle of a room in such a way that the women can approach it on all sides (Fig. 1224). Pigs of lead are thrown into this furnace, and are melted by the heat of a fire applied beneath. When melted the lead is laded by the women into flat iron moulds, so as to form pieces about twenty inches long, five broad, and an eighth of an inch thick: weighing about five pounds each. Some of the women are employed thus in casting, some in keeping the molten lead constantly stirred, and some in receiving the cast pieces when solidified.

The pieces of lead are built up in a singular manner in a lofty room. There is in the first place strewed over the floor of the room a thick layer of ashes; upon which is laid tanner's spent bark, to the thickness of two or three feet. On the bark is placed a number of earthen pots, as close as they can stand over the whole area of the room: these pots are about five inches in height, and each contains about a pint of vinegar. On the pots are laid leaden plates, piled up in heaps of six in depth, and laid close together over the open mouths of the pots. On the lead is laid a loose flooring of boards; on the boards a second layer of bark; on the bark a second layer of pots containing vinegar; on the pots a second layer of leaden pieces; on the lead a second flooring of boards. Thus does the building up of the "stack" (as it is called) continue, until a room twenty or thirty feet high is piled nearly to the ceiling; the room containing eight or ten "beds," and each bed consisting of the associated layers of bark, vinegar-pots, lead, and flooring-boards. All these numerous component layers are placed by women (Fig. 1223), who mount higher and higher in the room as the filling proceeds. Some of these rooms contain sixteen hundred pots and four tons of lead in each "bed;" so that the weight of the whole assemblage becomes enormous.

When the "setting of the beds" is finished, the room is completely and tightly closed in, and left untouched for many weeks. During this time the bark ferments, and keeps up in the room a temperature of about 180° Fahr. This warmth causes the vinegar to evaporate slowly; and the acetic vapour, coming in contact with the lead placed over the open mouths of the pots containing the vinegar, converts the lead first into an oxide and then into an acetate. Carbonic acid, arising from the decomposition of the bark, converts the acetate of lead into carbonate. Such at least is one explanation given, but it does not seem to be clearly determined what are the exact chemical changes that take place. The result, however, is, that every plate of lead becomes thickly coated on both surfaces with a white earthy-looking substance, which is a carbonate of lead formed by a combination of the main portion of the lead with carbonic acid.

To separate this carbonate from a thin film of metallic lead which still remains unaltered between the two surfaces, is the object of the next process. The "stack" is separated piecemeal, and the pieces of lead are removed to another room; where they are passed between a pair of brass rollers revolving in water; the carbonate becomes crushed and separated from the metallic lead; and the latter is removed from the vessel, while the former mixes with the water. The water being allowed to settle, the carbonate separates from it; and on being collected, ground, and dried, the carbonate assumes the form of "white-lead," which is either sold in the dry state, or is mixed up to the consistence of a thick paste with linseed-oil.

In the preparation of all the large variety of colours, some among the processes which have already engaged our attention are always adopted. Grinding by means of wheels and mills; steeping, boiling, evaporating, and other chemical processes; the addition or the separation of some ingredient to or from others—all are brought to bear on the attainment of the object in view.

Sulphur: Sulphuric Acid.

A very valuable and interesting class of substances is obtained, by the researches of modern chemistry, from *sulphur* as the main source. Sulphuric acid is among the most largely consumed acids employed in the arts, both in its simple form and as a component part of other substances; and as it is more readily prepared from common sulphur than from any other body, sulphur thus becomes a highly important commercial and manufacturing agent.

Sulphur is obtained in two different ways, one adopted in our own country and one in Sicily. The iron and copper pyrites, which form the ores of those metals which are so valuable to England, are compounds containing sulphur; and in the process of smelting the ore, the sulphur becomes separated from the metal. When melted in iron pots, it is cast into wooden cylindrical moulds which give it the form of rolls.

But by far the larger portion of the sulphur used in England is obtained from Sicily, where there are sulphur-pits, evidently connected in some way with the volcanic features of that island. The following is an account which has been given of one of these sulphur mines or pits, and of the methods pursued by the miners and manufacturers:—The mine is situated about three miles from Catolica, in a small isolated mountain about twelve hundred feet in diameter. At first sight it appears very much like a marble-quarry; the various colours which the sulphur assumes looking like the veins in marble, as it is seen mingled with the calcareous stones of which the mountain is partially formed, and with the potter's clay and gypsum which are also found at the same place. The general ground-colour is a beautiful grey, somewhat shining. Across this ground, veins of sulphur are seen, of various colours, some much brighter than others; the deepest coloured are nearly red and transparent, like a cherry-coloured cornelian. The miners call this ore "virgin sulphur." There are also large black spots, which consist of clay combined with sulphuric acid; and in the midst of these black masses hollows are found, partially filled with beautiful crystals of gypsum, some white, some black, others grey, or yellow, or violet.

Such is the nature of the ore found in the mountain. When the mine has been quarried, preparations are made for burning the fragments. A row of round furnaces is formed, which resemble great cauldrons six or seven feet in diameter. A small opening is made in the front of each of these furnaces, which is closed up with earth tempered with a little water. This being done, the largest of the superfluous fragments are placed on a little ledge which goes round the bottom of the furnace; stones of smaller and smaller size are successively laid upon these; until by degrees a kind of vault or cupola is formed over the furnace, having a small hole in the top. Very small stones are now thrown over it, and at last merely the dust of the ore, so as to form altogether a kind of pyramid. When the ore is thus arranged, a conical band of very fine earth is formed round the base of the pyramid; this belt, which is about six or eight inches in width, prevents the vapour of the sulphur from escaping too easily from the bottom of the furnace. A large handful of straw is placed on the pyramid, and set on fire: this inflames the outer part of the pyramid, and the fire soon extends to the interior. When the fire has continued for seven or eight hours, the sulphur is found to have left the ore, and to have fallen to the bottom of the furnace in a liquid state. A small hole is then made with a round bar of iron through the earth with which the opening in front of the furnace had been stopped; through this hole the sulphur flows, and is received in wooden moulds which are previously moistened to prevent the adhesion of the sulphur to them. In fifteen minutes the sulphur has solidified sufficiently to be removed from the mould.

The sulphur thus produced, when brought to England, is applicable to a great variety of purposes, one of which is the manufacture of sulphuric acid. This valuable acid (popularly known by the name of "oil of vitriol") is a compound of sulphur with oxygen; and the manufacturing arrangements are such as will lead to the combination of these two simple substances.

The sulphur is thrown into square iron furnaces, air-tight or nearly so; and on being kindled, it burns gradually away, leaving only a residue or ash in the furnace. The sulphur becomes by this burning converted into a vapour formed of sulphur and oxygen, constituting "sulphurous acid;" and the subsequent processes are for the transformation of this into "sulphuric" acid, by the addition of more oxygen. Behind the furnace is a hollow chamber into which the sulphurous acid fumes ascend, and from which they pass into vessels formed by sheet-lead (Fig. 1220). In some of the sulphuric acid works the leaden chambers employed extend to a length of two hundred feet, with a width and height of about twenty: they are made of lead, because this metal has the property of resisting the acid power of the fumes. A very complicated series of changes occurs while the sulphurous acid is contained in these enormous vessels: a little nitrate of soda, a little steam, and a little atmospheric air are admitted into the chamber, under such circumstances that the acid obtains a further portion of oxygen, by which it is converted into sulphuric acid, which combines with water at the bottom of the vessel into the liquid form.

So corroding is the action of these acids, that leaden pipes are required to convey the fumes from the furnace, leaden chambers into which to receive it, and a leaden tank for receiving the liquid sulphuric acid from

the chamber. If the acid is required to be stronger or more concentrated, a new difficulty arises; for though lead will resist the action of the acid itself, it would not resist the action of the heat requisite for the concentration; while almost all other metals, even if they could bear the heat, would be corroded by the acid. Under the operation of this difficulty, the manufacturers formerly employed glass stills for the concentration, but the expense of the frequent breakages was such as to render some other method desirable. At length Dr. Wollaston discovered a mode of bringing *platinum* into a malleable form; and as this metal will resist both acid and heat, it was eagerly sought after as a material for sulphuric acid stills. But the difficulty of the manufacture is such as to render this material very costly. Sometimes a still weighing a thousand ounces will cost a thousand guineas; and indeed it is not unusual to estimate, in round numbers, the expense of a platinum vessel to be as many guineas as it weighs ounces. Yet so invaluable is this material to the manufacturers—as being the only one yet known that will resist both fire and acid to the requisite degree—that the use of platinum for such purposes has become general. The costly platinum still is enclosed in an outer casing to preserve it (Fig. 1221). Here the sulphuric acid is concentrated to any desired strength for the market; usually to about twice the specific gravity of water.

Bleaching-powder: Soda: Muriatic Acid.

One of the most notable examples of the benefit resulting from making things cheap—not by deteriorating the quality, but by lowering the duty—has been afforded by the common *salt* with which we are all familiar. When the duty was so high as to make the retail price of this article four or five pence per pound, salt was not much used except in the complete or combined form of salt; but now that (owing to the removal of the duty) it can be purchased at an extremely low price, manufacturers find it worth while to disentangle the salt (if we may so express it) to see what it is composed of, and to manufacture useful products from one or other of the component ingredients. It is in this way, and by these steps, that the manufacture of chlorine, of bleaching-powder, of soda, and of muriatic acid have so largely extended within the last few years.

Common salt is chemically a "chloride of sodium," and all the substances just named require one or other of these two components—chlorine and sodium. The first step, therefore, is to separate the salt into its two parts, and then to apply one or both of these to practice: it is thus that the same manufacturer finds it advantageous to make all these four varieties of chemical agents. The salt is thrown into a leaden pan deposited within a reverberating furnace; and sulphuric acid is let down upon it through a leaden pipe from a hole in the roof of the furnace. The salt dissolves in the acid; and from the liquid compound is formed a new acid—muriatic acid—which ascends in the form of vapour, and is made to pass through a filtering medium in such a manner as to combine with water: forming in that state the liquid muriatic acid, or "spirit of salt," of the shops. This remarkable change is brought about thus: the sulphuric acid takes away the sodium from the salt, and forms with it a sulphate of soda; while the chloride of the salt combines with hydrogen to form muriatic acid.

The muriatic acid, thus formed from common salt, is in its turn made to produce chlorine and bleaching-powder—those substances so invaluable as bleaching agents. Muriatic acid and oxide of manganese are placed in stone vessels which are contained within other vessels of iron. Steam is admitted into the vacant space between the vessels; and by the heat from this steam a complicated series of chemical effects is produced: the oxide of manganese gives up its oxygen, the muriatic acid gives up its hydrogen; these two combine to form water, and the chlorine of the acid is left separate in the state of a gas. Scarcely any of the gases are more corrosive and deleterious than this; and it requires the utmost care in the management of the processes.

As it would be difficult to keep and transport the chlorine in this gaseous form, some mode had to be devised of making it more convenient and portable without lessening its valuable bleaching qualities. This was happily effected by Mr. Tennant of Glasgow, who showed that lime might be made to absorb chlorine gas in large quantity, without interfering with the purposes to which the chlorine is mainly applied. In effecting this process, the chlorine gas, as it escapes from the vessels in which it is made, is received in air-tight chambers, in which are shelves containing bags filled with slaked lime. The chlorine acts upon and impregnates the lime, until the two combine chemically together, and form the white substance known as "chloride of lime," or "bleaching-powder." This powder, when immersed in water, dissolves, and imparts to the water all the bleaching properties itself possessed; so that, whether in the solid, the liquid, or the gaseous form, chlorine is still possessed of that wonderful power (as illustrated in Chapter III.) of removing colour. Its property is not less remarkable of removing odour. Numerous instances and numerous processes connected with manufactures have within the last few years been rendered less offensive in respect to odour than before, by reason of the use of chlorine.

These two substances, then—muriatic acid and chlorine—result from one of the component ingredients of common salt; and we have next to see how soda and carbonate of soda are obtained from the other.

When the chlorine has been driven away from the mixture of salt and sulphuric acid in the furnace, the residue, forming an impure "sulphate of soda," appears as a pasty mass. This is mixed up with lime and coal, both in the state of powder, and the mixture is exposed to heat in such furnaces as those shown in Fig. 1234. The heap is stirred by men with long-handled rakes, and the small coal ignites by the heat of the combustion. The result is a rather complex series of changes among the contents of the furnace, arising from the difference of affinities among the ingredients one for another. When the contents of the furnace have arrived at a semi-fluid state, the door of the furnace is opened, and they are drawn out by means of a rake into a shallow tray placed upon wheels; the mass solidifies in these trays into large flat cakes of a brownish colour.

The cake consists principally of carbonate of soda and sulphuret of calcium, and is called "ball soda," or "crude soda;" and the sulphuret requires to be removed before the soda can assume a purer form. To effect this removal, the crude soda is immersed in water, which dissolves the carbonate without affecting the sulphuret; the liquor is drawn off, more water is applied, and so on, until the crude soda has been made to yield the whole of its carbonate. The liquor so obtained is exposed to the action of heat in an open evaporating vessel; by which all the water is driven off, and nothing remains but carbonate of soda mixed with a little sulphur. This sulphur is driven off by the further heat of a furnace; and the yellowish earthy substance which remains is "soda-ash," or "soda-salt," used in a variety of manufactures.

For other purposes the soda requires to be brought to a purer and crystalline form. The soda-ash is dissolved in water, allowed to settle, and boiled to a certain degree of consistency. The liquid is poured into large cast-iron hemispherical vessels (Fig. 1233), where it remains several days; at the expiration of which time it is found to be converted into beautiful crystals of carbonate of soda, which is then fitted to be employed for finer purposes than those to which soda-ash is applicable.

Oil Mills: Oil from Crushed Seeds.

It would be impossible to follow to much greater length the manufactures connected with the production of the various acids, alkalis, salts, and oxides. They are so numerous, and the general character of the processes has such a uniformity in principle, that it is neither practicable nor necessary to extend the details: those which have been described will serve as examples of all.

There are, however, many interesting products which, while they owe their origin to vegetable growth, require certain mechanical or chemical arrangements for bringing them into usable form. Such are seed oils, resins, turpentine, tar, pitch, balsams, gums, &c.

Oil, it may be remarked, is of two different kinds: that obtained from animals, such as the whale, the seal, and the pilchard; and that obtained from vegetables. Vegetable oil, again, is of many different kinds; some varieties being procured from the fruit, others from the kernel of the fruit, others from the bark, from the roots, &c.; but that which is procured from seeds is the most plentiful of vegetable oils. Olive-oil, as made in the south of Europe, will illustrate what is perhaps the most valuable vegetable oil of the Continent; while linseed-oil will serve to exemplify the process of obtaining oil from seeds in England.

In France, Italy, and Spain, the olive is cultivated for the sake of the oil; the plant being allowed to grow until the fruit has become a small green oval berry, containing a hard stone, in which are two seeds. The fruit is gathered a little before it is ripe, and spread on the floor of a room, where it is left for several days to dry and to ferment slightly. The olives are then crushed in a mill; and the mass is put into bags made of rushes or of coarse canvas, which being subjected to pressure in a screw-press, the oil flows out and is received into proper vessels half filled with water, on the surface of which the oil floats, and is easily skimmed off. Where the process is carefully performed, the stone of the berry is not broken when the fruit is first put into the mill, the millstones being set wide enough apart to avoid doing so; and the oil first drawn off is of a superior quality. After all this is expressed, the mass, stones and all, is either returned to the mill and the stones are broken, or the same effect is produced by mixing up the mass with boiling water, and increasing the power of the press. By repeating this operation, not only a second, but even a third quality of oil is obtained.

The principal oil obtained from seeds in England is linseed-oil: other varieties, such as hempseed and rapeseed oils, being less in request. Linseed is the seed of the *linum*, or flax-plant; and thus this plant has the twofold virtue of supplying us with all our linen and all our linseed-oil; the one from the fibres of the stem, and the other from the seed. When the plant is grown for the sake of the oil obtainable from the seed, the details of culture differ somewhat from those instances in which the fibres are required for linen. The plants, when properly grown, are pulled up, and laid together with the seed end towards the south; or else they are piled up like a wheatsheaf. When they have become partially dried by this exposure to the air, they are brought in-doors, and the seeds are separated from the other parts of the plant. This is effected by means of an instrument called a "ripple," which is a kind of comb, having long wire teeth, through or between which the plants are drawn, whereby the pods containing the seed are removed from the rest of the plant. The seeds and pods so collected are spread out in the sun to dry; some of the pods open when dry, and yield up the seeds readily; while others require to be slightly thrashed, to loosen the seed from the husk. When the separation is completed, the whole are sifted, winnowed, and cleansed; and the seed is in that state ready to be submitted to the requisite processes for extracting the oil.

The linseed is too hard to be crushed in the same manner as olives: it requires a heavier pressure and a different mode of procedure. In some oil-mills the crushing is effected by a "wedge-press," and in others by an "hydraulic press. On the former of these two methods, the seeds are first pounded in hard wooden mortars by means of pestles shod with iron and set in motion by horse or water power. The triturated seeds are then put into woollen bags, which are wrapped up in hair-cloths, and then submitted to the action of the wedge-press. This kind of press consists of a strong block of wood or a cast-iron frame, in which a long mortice is made; and two bags of seed are introduced at the two ends of the frame in such a manner that by forcibly driving in some wedges the seed became pressed with immense force, and yielded its oil abundantly.

As more usually conducted at the present day, however, the extraction of the oil from the linseed is managed in the following manner:—Before being ground the seed is bruised by being passed between two crushing rollers, placed side by side, in such a manner that the seed, passed between them from a funnel above, becomes crushed in the passage, and falls in a bruised state into a box beneath. This process is necessary; because the seed, if attempted to be ground without a preparatory bruising, has a tendency to slip away under the rolling action of the grindstone. The seed, when bruised, is transferred to another machine, where a pair of edge-stones roll over a bed-stone placed beneath them (Fig. 1226). The seed is placed on the bed-stone; and the stones, rolling over it in a circular path, grind it to the requisite state of fineness.

The seed so bruised and ground is not a dry powdery mass; for the oil contained within it gives a paste-like consistency to the whole. The process to which it is next subjected depends on the circumstance whether "cold-drawn" bruised oil is required: if such is the case, the mass of seed is at once placed in the press, where a very small quantity of fine and superior oil is obtained from it. But by far the larger portion of the supply obtained, though somewhat inferior in quality, results from a previous heating of the seeds. To effect this heating, the seed is put into a rotating vessel so as to keep it constantly stirred while steam or some other heating agent is acting upon it; when heated, the seed is liberated from the vessel, and made to fall into a number of oblong flannel bags suspended from the lower part of the vessel (Fig. 1229).

To press the oil from the seed thus enclosed, the bags are flattened by hand, and built up into a pile one on another, in iron cases (Fig. 1228), which cases are then put into an hydraulic press of great power. The press is set to work, and the oil is speedily seen to be oozing through the pores of the bag, from whence it trickles down into a receptacle beneath. The oil being expressed by these means, the bags are removed from the press, and then present the appearance of very hard flat cakes. By an ingenious contrivance the bags are stripped off these cakes (Fig. 1227), and leave the latter in the form of oblong pieces. These pieces are ground up to powder, again heated, and again pressed, by which all the remaining oil capable of being obtained from them is removed. The spent cake, though incapable of yielding any more oil by pressure, still contains sufficient oleaginous matter to be serviceable as a fattening food for cattle and sheep; or if it is not good enough for this, it forms an excellent manure—so that the entire substance of the linseed, liquid and solid, becomes useful.

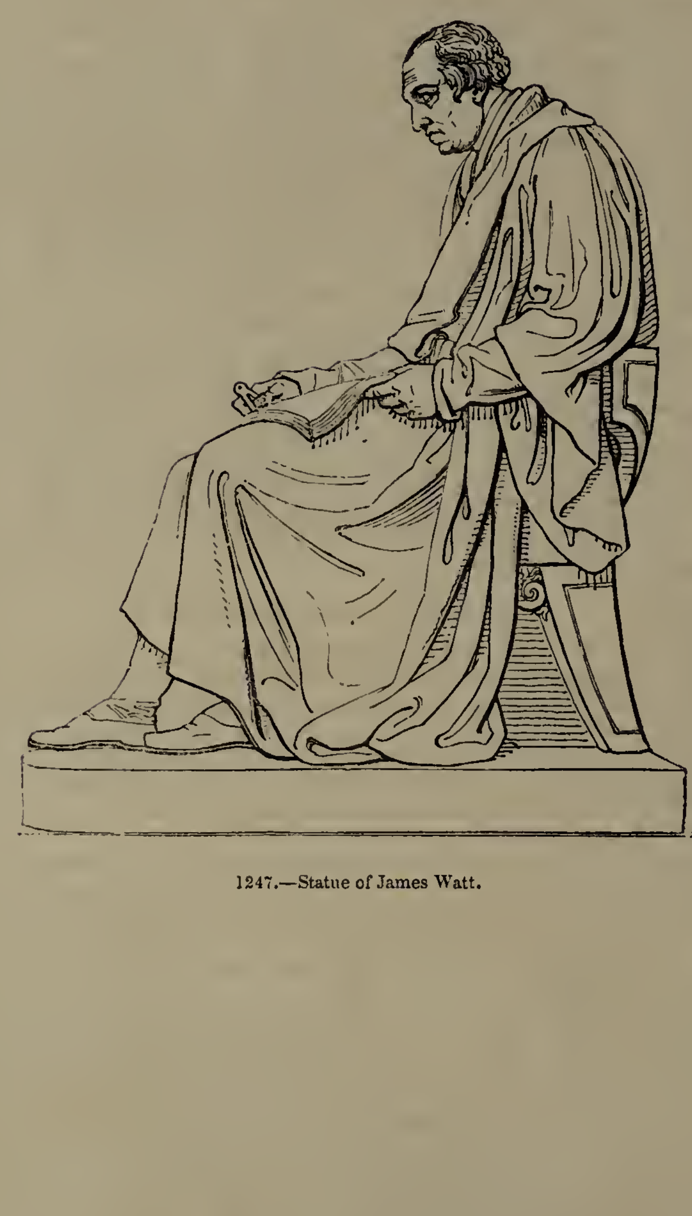
Some kinds of linseed-oil are required to be in a "drying" state; that is, capable of hardening more speedily when used in paint. To give this quality to

1243.—Fulton.

1244.—Watt.

1245.—Rennie.

1246.—Telford.



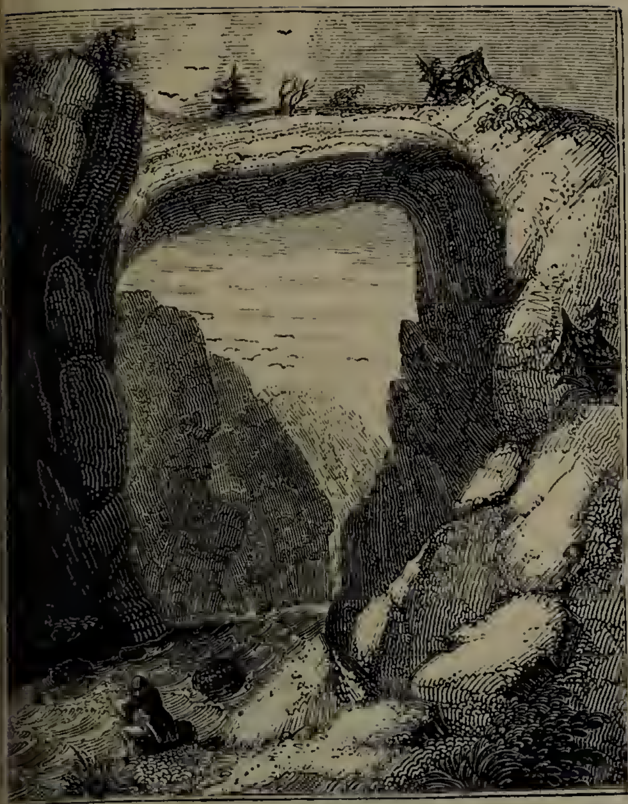
1247.—Statue of James Watt.

1248.—Harrison.

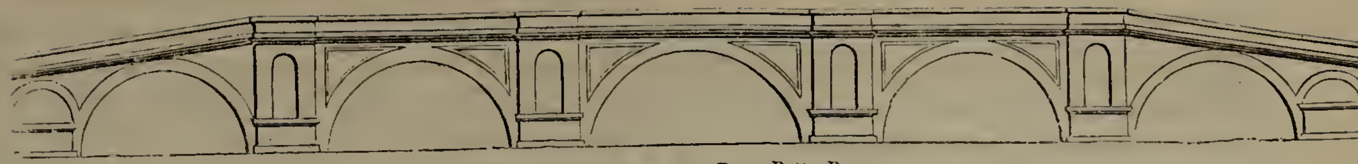
1249.—Brindley.

1250.—Boulton.

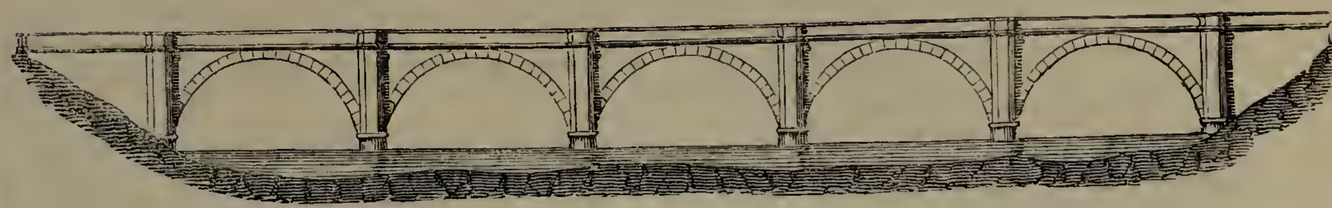
1251.—Smeaton.



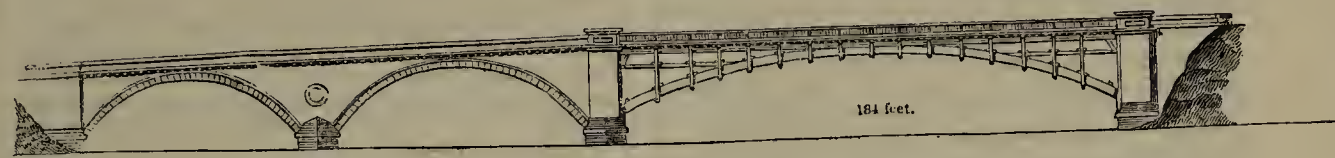
1252.—Natural Bridge in Virginia.



1253.—Pons Senatorius, now Ponte Rotto, Rome.



1254.—Bridge over the Don at Aberdeen.



1255.—Arches of the Old Bridge, Fochabers.

Arch of the New Bridge, Fochabers.

1256.—The Rialto or Principal Bridge at Venice.

1257.—Triangular Arch.

1258.—Schuylkill Bridge, Pennsylvania: one half showing the construction; the other half, the external elevation.

the oil, it is boiled with sugar of lead, white vitriol, red-lead, or some other substance which is found by experience to effect the required change in it.

Caoutchouc and its Manufacture.

Among the many vegetable exudations which are applied to a useful purpose is *caoutchouc*, or India-rubber. There are several varieties of tree in America which yield this singular gum. The substance was not known in Europe until about a century ago; when, on the occasion of the visit of some French men of science to South America, they became acquainted with the gum caoutchouc and with the mode of obtaining it.

In order to obtain this gum, the trees which produce it (of which one variety is sketched in Fig. 1231) are pierced during the rainy season. A thick juice of a yellowish white colour exudes from the wound, and becomes darker by exposure to the air. If this juice be kept in well-corked bottles, it may be preserved for some time without undergoing much change, and it has occasionally been imported in this state; but however perfectly the atmosphere may be excluded, the caoutchouc will ultimately solidify. Heat, alcohol, and acids are all sufficient to solidify it. If the gum be exposed to the air in thin films, it soon dries, losing thereby from one-third to one-half of its weight; and the natives of Brazil avail themselves of this property in collecting the gum. They apply it in successive coatings to the surface of clay models of bottles and of animals: these are dried over a fire, the smoke of which communicates a dark colour to the caoutchouc; and while the substance is yet moist, various lines are drawn upon it with a blunt tool, which remain permanently impressed. When the whole has become dry, the clay is crushed and shaken out of the bottles; and the latter then assume that form with which we are familiar in caoutchouc as imported for sale.

A very remarkable extension has within the last few years taken place in the use of caoutchouc in the arts. Its elasticity is remarkable, and has been taken advantage of in a great variety of ways. For some purposes caoutchouc is useful because it is impervious to water; for others, because it is very elastic; and it is not difficult to see which of these qualities is brought into requisition in any particular instance.

One of the first purposes for which this material was found valuable was in giving a "waterproof" quality to capes and other garments. The Brazilians have long made boots and cloth waterproof, by impregnating them with this gum. The waterproof or "Macintosh" cloth of this country is made by laying upon a piece of cloth, spread out flat upon a table, a coating of caoutchouc dissolved in the oil distilled from gas-tar; and then pressing or rolling together two pieces thus coated, the two surfaces of caoutchouc being in contact: the cloth is thus a double-cloth, having a thin wall of caoutchouc between the two thicknesses. When thus prepared, the double-cloth is both waterproof and air-proof, and is in that state applied to a great variety of purposes. Floating or hydrostatic beds are made of it, containing water within, not a particle of which can escape through the pores of the cloth. Air-tight cushions and beds are formed of the cloth, having no aperture except through a small tube by which the article is inflated. Air-tight bandages for surgical operations are similarly made. Waterproof safety or life boats are among the numerous articles similarly formed: one example of these will serve to illustrate the manner of bringing the imperviousness of the caoutchouc into use. There is one kind of pontoon or safety-boat formed of a skeleton frame, easily detached and folded into one-sixth of the space which it occupies as a boat. The frame is covered with layers or folds of strong canvas saturated with caoutchouc; and in various parts are cases or air-cells, partitioned off one from another. The thickness of the canvas is increased according to the size of the boat, so as to give it a great degree of toughness, and at the same time an elasticity fitted to yield to any sudden shock without fracture. The portability of the boat is ensured by having the framework hinged to the keel, so that the sides fold together like a portfolio; various minor arrangements being made to give fixity to the shape when the boat is in use. A boat of this kind, tried in France in 1841, was more than a hundred feet long; and although formed of canvas sides, it was loaded with nearly one hundred tons of wood and wine, which it safely conveyed from Auxerre to Paris, down a shallow and much interrupted stream: it was then taken to pieces in three or four minutes, and all the materials packed in two carts, which took it to Auxerre for another cargo.

Numerous other modes are adopted of bringing into use the power which caoutchouc possesses of resisting the penetration of water; and no less varied are the contrivances which depend for their value on the *elasticity* of this material. Woven materials in great number are now made, having an elastic quality which is due to a filament of India-rubber being combined with filaments of cotton or of worsted in the process of spinning. The modes of doing this are very curious. In the infancy of this art, the bottle-shaped masses of India-rubber were cut up into slips by means of scissors, and the different layers or coatings of the gum separated one from another. Another plan consisted in softening the bottle, inflating it with air to the requisite degree of thinness by means of a forcing-pump, and then cutting it up into strips. The plan now adopted, however, is the following:—The bottle, being softened in hot water, is cut into two halves, each of which is pressed between two iron plates until it assumes a flat circular form. This flat circle is cut into a continuous ribbon, by means of a cutter working spirally from the circumference towards the centre; the ribbons so prepared are cut into filaments or threads of the desired width by passing them through a machine having a number of parallel cutting edges. The threads are next softened in warm water, and stretched by a winding-machine to many times their original length; and being kept in that tended state till cool, they do not spring back again when released. They are next attached to a braiding-machine, and are sheathed with threads of cotton, silk, linen, or other material. The threads so sheathed are then used as "warp," or long threads, and are woven into a great variety of useful articles. By passing a heated iron over the woven goods, the caoutchouc relaxes, the sheathing curls or shrivels up, and the whole acquires a great elasticity. Sometimes a band or thin belt of this material is used, to give elasticity to an article made in other respects of common woven materials; such, for example, as the elastic bands at the top of cotton gloves.

There are many other purposes to which India-rubber or caoutchouc is applied in the arts; but the above will serve to illustrate the more important among them.

Resinous Products from Trees.

The substances which are obtained from trees in a manner more or less resembling that by which caoutchouc is derived, are many and varied. *Tar*, *pitch*, *lampblack*, *resin*, *turpentine*, *Burgundy pitch*—all are obtained from such sources; some while the tree is yet living, and others after it has been cut down.

Tar is among the latter of these two classes. It is a thick black gum obtained from the dead fir-tree; and is very largely produced in Russia, from whence our chief supply is brought. Dr. Clarke describes in the following manner the mode adopted in procuring it:—"The inlets of the Gulf of Bothnia are surrounded by noble forests, whose tall trees, flourishing luxuriantly, cover the soil quite down to the water's edge. From the most southern parts of Westro-Bothnia to the northern extremity of the Gulf, the inhabitants are occupied in the manufacture of tar, proofs of which are visible in the whole extent of the coast. The process by which the tar is obtained is very simple; and as we often witnessed it, we shall now describe it, from a tar-work we halted to inspect upon the spot. The situation most favourable to the process is in a forest near to a marsh or bog; because the roots of the fir, from which tar is principally extracted, are always most productive in such places. A conical cavity is then made in the ground (generally in the side of a bank or sloping hill); and the roots of the fir, together with logs and billets of the same, being neatly trussed in a stack of the same conical shape, are let into this cavity. The whole is then covered with turf, to prevent the volatile parts from being dissipated, which by means of a heavy mallet, and a wooden stamper worked separately by two men, is beaten down and rendered as firm as possible above the wood. The stack of billets is then kindled, and a slow combustion of the fir takes place, without flame, as in making charcoal. During this combustion the tar exudes; and a cast-iron pan being at the bottom of the funnel, with a spout which projects through the side of the bank, barrels are placed beneath this spout to collect the fluid as it comes away. As fast as the barrels are filled, they are bunged and made ready for exportation. From this description it will be evident that the mode of obtaining tar is by a kind of distillation *per descensum*; the turpentine, melted by the fire, mixing with the sap and juices of the fir; while the wood itself, becoming charred, is converted into charcoal." Some of these processes are depicted in Fig. 1232. Dr. Clarke, after stating that tar was made by the Greeks more than two thousand years ago, remarks that "There is not the smallest difference between a tar-work in the forests of Westro-Bothnia and those of ancient Greece. The Greeks made stacks of pine, and having covered them with turf, they were suffered to burn in the same smothered manner; while the tar, melting, fell to the bottom of the stack, and ran out by a small channel cut for the purpose."

The Americans obtain tar from the Carolina pine, and the country-people of Scotland from the Scotch pine, in modes resembling in principle that above described, although differing slightly in the details. The Scotch hew the wood into billets, put these into a pit dug in the earth, and ignite them; the top is covered with rude tiles; and the tar, as it leaves the wood, flows out at a small orifice in the bottom of the pit. In the American method, the wood is collected, stripped of its sap-wood, cut up into billets of convenient length, and piled up on the surface of a raised mound to the height of ten or twelve feet, with a diameter of twenty or thirty. The pile is covered with clay, beaten down closely, and the wood is kindled at the top, whence it burns down through the mass slowly; the tar, as it melts and flows out, collects in a circular trench, which surrounds the pile, whence it is removed.

From tar, prepared by any of these methods, pitch and lampblack are obtained. Pitch is the solid residue obtained by evaporating or distilling tar, just in the same way as resin is the residue left in the still in the process of distilling turpentine, presently to be described. Lampblack is the soot of burned tar, and is prepared in France in the following manner:—There is a furnace, the chimney of which carries off the smoke from the fireplace into a chamber which has an opening in the roof: over the opening is placed a flannel bag, supported by wooden rods in form of a pyramid, and composed of four pieces of coarse flannel sewn together. The best lampblack is made by burning straw through which tar has been strained. To effect this the tarred straw is put into the stove and kindled; the smoke passes from the stove through the chimney into the chamber, where it deposits its soot on the walls and on the flannel bag: the flannel acting as a filter to the lighter part of the smoke, by retaining the soot, and permitting the heated air to escape into the atmosphere. The soot is detached from the flannel bag by striking the outside smartly with a stick; and, the door of the chamber being opened, the lampblack is swept out, and packed in small barrels made of fir-wood for sale. Sometimes lampblack is obtained by burning resin in a kind of lamp, having a tin tube attached by way of chimney; the end of the tube is fixed in a close box, having an opening in the top surmounted by a flannel cone; the lampblack is collected in this cone; and it was from this mode of obtaining lampblack that the name was derived.

The different kinds of *turpentine* are all procured from living trees: the common turpentine from the Carolina pine, in America; the best turpentine from another species of tree in Cyprus; Venice turpentine from the larch; Strasburg turpentine from the silver fir; and Burgundy pitch from the spruce-fir. All these are obtained, under various modes of arrangement, by incisions in the living tree.

The mode by which the Italian peasants obtain Strasburg turpentine, as described by the late Mr. Loudon, is curious and interesting:—Towards the month of August in every year the peasants proceed towards the fir-forests in the Alps, carrying with them sharp-pointed pouches called "cornets," and tin vessels suspended from girdles round the waist. Thus accoutred, they climb to the summits of the loftiest fir-trees, their shoes being armed with cramping-irons like spurs, which penetrate the bark of the tree, and thus support the wearer. The resinous fluid is contained in small tumours or blisters, under the epidermis of the bark; and the peasant, clinging to the trunk of the tree with his knees and one arm, presses the sharp extremity of the cornet against the little tumour. An incision being thus made, the cornet is soon filled with the clear turpentine which flows from the blister. The man then empties the treasure into the tin bottle slung to his waist, and proceeds to another tumour in a similar manner. When the bottle is full, the turpentine is strained into a large leathern or goatskin bottle: this straining is to free the turpentine from the leaves or moss and bits of bark which may have fallen into the bottle; and this is the only preparation that is given to this kind of turpentine, which is kept in the skin or leathern bottles for sale.

The kind called "Venice turpentine" will illustrate another mode of obtaining this vegetable product. This is obtained from the trunk of the tree, instead of from the branches and shoots. In the mountain-valleys between France and Savoy the peasants use augers nearly an inch in diameter, with which they pierce full-grown larch-trees in different places, beginning at a height of three or four feet from the ground, and mounting gradually to ten or twelve feet. They choose generally the south side of the tree, and, where practicable, the knots formed by branches which have been broken or cut off, and through which the turpentine easily exudes. The holes are always made in a slanting direction, in order that the turpentine may flow out of them more readily, and care is always taken not to penetrate to the centre of the tree. To the holes thus bored are fixed gutters made of larch-wood, an inch or two in width, and about half a yard long; one of the ends of each gutter terminates in a peg, through the centre of which a hole is bored, half an inch in diameter. This end of the gutter is fixed into the hole made in the tree, and the other end is let into a small bucket or trough, which receives the turpentine. "A very picturesque scene," it has been observed, "is presented in a larch-forest, in fine spring weather, by the vast number of little buckets at the foot of the trees, each attached to a tree by a slender tube or gutter, through which the clear limpid turpentine, glittering in the sun, trickles down into the bucket; while every morning and evening the peasants hasten from tree to tree, examining their buckets, taking away or empty-

ing those that are full, and replacing them with empty ones. This scene continues from May to September, during which a full-grown larch will yield about seven or eight pounds of turpentine, which requires no other preparation to render it fit for sale than straining it through a coarse hair-cloth to free it from impurities. If it happens that turpentine does not flow from a hole, the hole is stopped with a peg, and not re-opened for two or three weeks; after which the turpentine is found to have collected in considerable quantity.

The common turpentine, obtained from Canada and the United States, is similarly derived from incisions made in trees, but with modifications of the process which need not much remark here. Cavities are made in the trunks of the trees; and in these cavities, in a period of about a fortnight, the turpentine collects so as to fill them; each being capable of containing two or three pints. As each cavity fills, it is emptied and allowed to fill again by the percolation of the turpentine down and through the trunk of the tree: thus the collecting continues throughout the summer. The variety known by the name of "Burgundy pitch" forms between the bark and the soft wood of the spruce-fir. A strip of the bark is taken off; and in the groove thus formed the Burgundy pitch collects in the state of a thick gummy mass, not so limpid as most kinds of turpentine.

The liquid known as "turpentine," used so largely in oil-paint, is not the turpentine as brought over from America, but a more purified preparation from it—one, too, which at the same time gives us the valuable substance "resin." The turpentine is brought over from America in barrels or casks; and appears, when the casks are opened, as a stiff, adhesive, honey-like paste, midway between solid and fluid consistency. It consists of two chemical principles—a solid resin and a perfectly liquid spirit or essence; and a process of distillation is necessary to separate the two. The turpentine is put into a large still or distilling vessel, and exposed to a heat which will vaporise the spirit or lighter portion; this vapour passes from the still through a refrigerator or cooling vessel into a receiver, where it collects as a liquid known in commerce by the name of "spirit of turpentine," or "essence of turpentine." The substance remaining in the still assumes a solid form, and becomes "black resin" or "yellow resin," according to the kind of turpentine put into the still.

Vessels required in Chemical Manufactures.

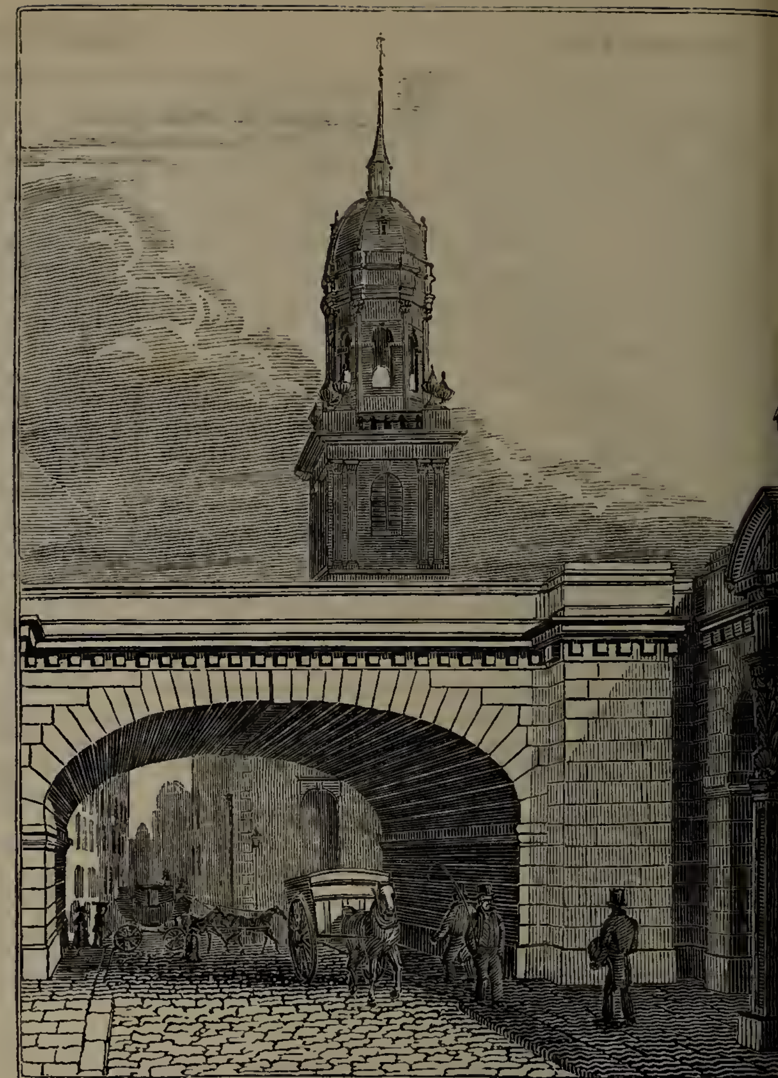
Here we terminate this Chapter. It will be seen that the preparation of substances requiring more or less of chemical aid embraces a very wide field, and calls into requisition almost all the various modes of treating the crude materials which are presented to us by nature.

The vessels and apparatus required in many of these processes are peculiar and valuable. Allusion has been before made to glass, to platinum, and to fire-clay, as materials for vessels; and if we glance at the eight cuts represented from Fig. 1235 to Fig. 1242, we shall see how very varied are the forms given to such implements. Some are stills formed for such purposes as the one lately alluded to; some are for filtering, for pounding, for sifting, for separating, for combining, for decanting. The pestles and mortars are often so formed as to prevent the material flying about out of the pestle; the sieves are occasionally so closed in that no particles from within them can mix with the air of the room. The rolling-stones or running-stones which are employed to grind materials to powder have various shapes according to the immediate object in view. Sometimes a siphon is used to decant liquid from one vessel to another; sometimes a tube is used with such a fine bore at the lower end that liquid will flow from it only drop by drop. The "retort-stands," by which small vessels are held over the flame of a spirit-lamp, are another example of the ingenuity which is so frequently manifested in these chemical manufactures.

Most of those here alluded to are instruments and vessels more suited for the numerous but comparatively small quantities operated on by the chemist and druggist, than for the more extended operations of the manufacturing chemist; but both classes alike call for great ingenuity, both in the form of the implements and the materials of which they are made. *Crucibles*, for instance, or the vessels in which substances difficult of fusion are melted in powerfully heated furnaces, are made of common clay, of porcelain, of Cornish clay, of Stourbridge clay, of black-lead mixed with clay, of silver, and of platinum, according to the intensity of heat to which they are to be exposed, and the kind of substance to be melted in them.

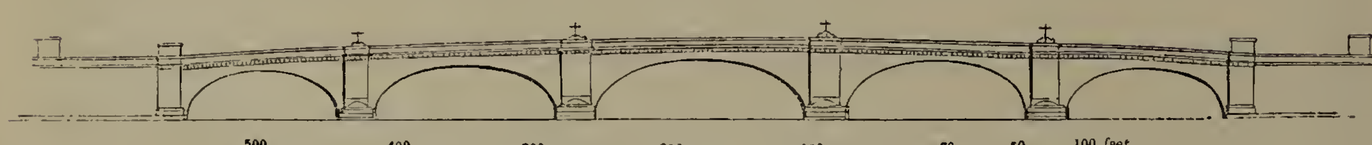
Whether a substance, then, is dug out of the earth in a hard and dry state, such as marble, stone, or gems; or is obtained in a state which enables it to assume a soft consistency for working, such as pottery and porcelain clays; or requires more or less of chemical or liquid preparation—it appeals no less to the resources of industrial art than those other materials which have engaged our attention in previous Chapters.

1259.—Old London Bridge, about 1616.

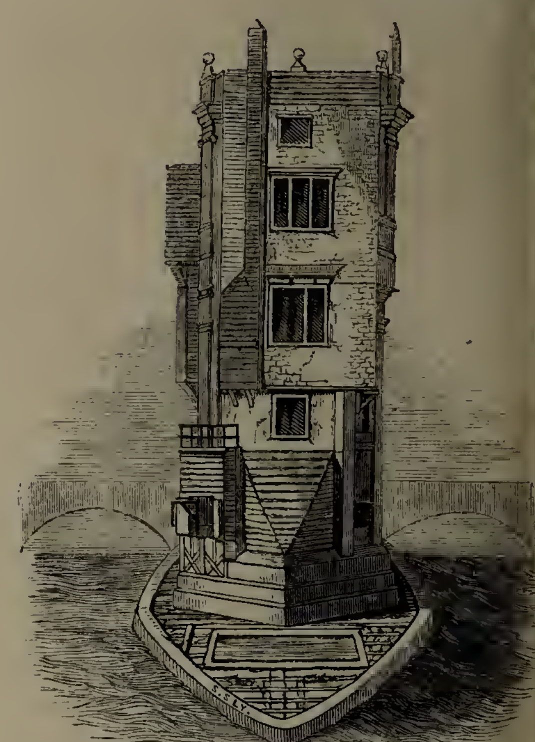


1260.—New London Bridge: Arch over Thames-street.

1261.—Old London Bridge, about 1760.



1263.—Elevation of New London Bridge.



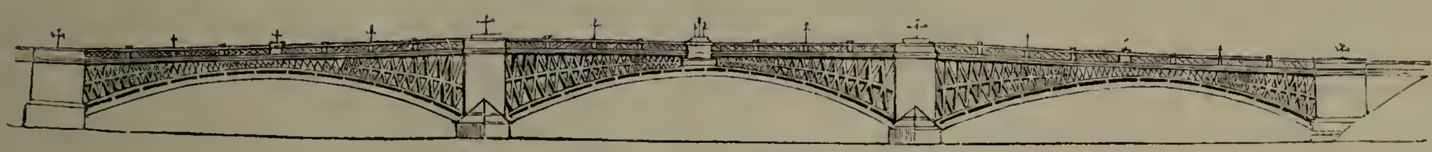
1262.—Chapel (afterwards a Warehouse) on Old London Brid

1264.—Old London Bridge, 1827.

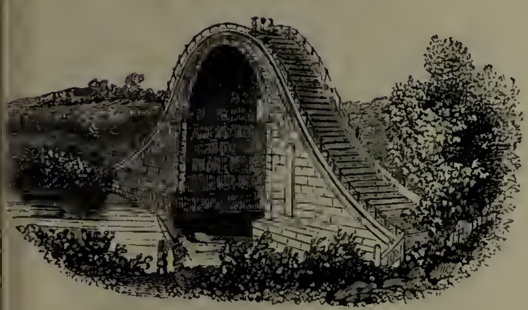
1265.—Opening of New London Bridge.

1266.—South American Rope-bridge.

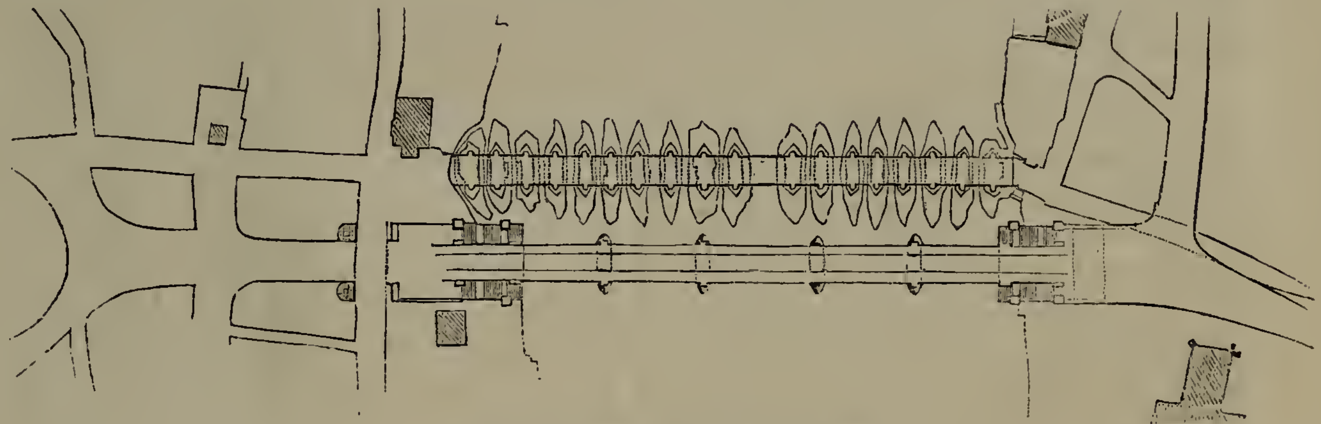
1267.—Southwark Bridge.



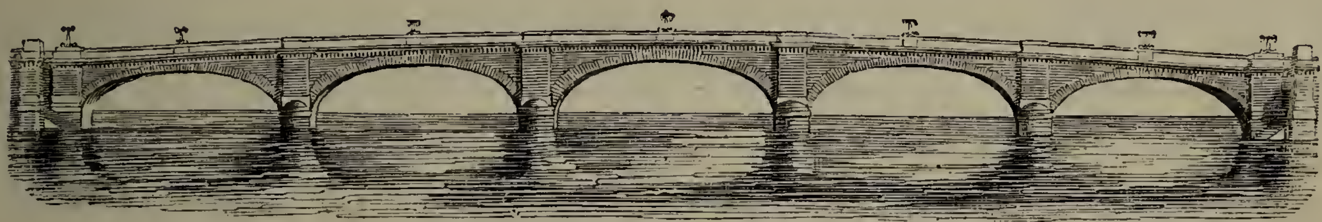
1268.—Elevation of Southwark Bridge.



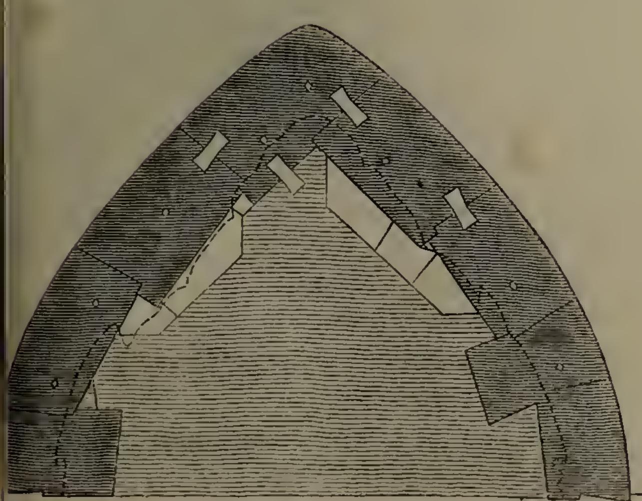
1269.—Chinese Bridge.



1270.—Plan of the two London Bridges, Old and New.



1271.—London Bridge.



1272.—The repairing of Blackfriars Bridge.

1273.—Blackfriars Bridge in 1839.

CHAPTER IX.

THE ARTS RELATING TO CIVIL ENGINEERING.

THE term "Civil Engineering" is not a very happily chosen one by which to designate the vast and important range of subjects which it embraces. Engineering was an expression first applied in military matters, and related to the scientific and mechanical details involved in the management of engines of war, or in the construction of such buildings and fortifications as should be able to resist the action of these engines. As the constructive arts were largely employed in these objects, especially in the erection of ramparts, bastions, barbicans, drawbridges, and other defensive buildings, the same name of "engineering" became customarily applied to the large works connected with bridges, docks, harbours, canals, lighthouses, viaducts, &c.; similar to the former in respect to the science and art required for their construction, but applied to a different purpose. As a means of distinguishing the one great branch which related to the arts of war from that which was devoted to objects of peace and commerce, the former obtained the name of "military" and the latter that of "civil" engineering.

If we seek to determine the exact relation which civil engineering bears to common building, we find that it involves a very much larger exercise of scientific skill. The laws of mechanical equilibrium, of vertical and oblique pressure, of friction and of adhesion, of the pressure and equilibrium and flow of water, of the resistance of air to bodies in motion, of the strength of materials, and a large number of others very varied in character, must be studied closely by the engineer before he will become competent to manage the great works which are placed under his care. He compares, and tests, and institutes experiments; and when he has brought the various branches of science to bear on his subject, he lays down rules for the "contractor," or person who undertakes the practical construction of the works. What the architect is to the builder, the civil engineer is to the contractor: he must not only decide what work shall be done, but he gives, in his "specifications," very minute instructions how to do it.

It is a subject of great interest to watch the struggles by which our eminent engineers have surmounted the obstacles offered to their progress. Let us take, for example, the men whose portraits are given in page 308 (Figs. 1243 to 1251). Each one presents to us a name connected with some branch or other of engineering; a branch which he did much to elevate to a position which it had not before attained. It is impossible to read the commercial history of our country for the last eighty years without seeing how much we owe to such men as these. The connection of Watt and of Boulton with the steam-engine, of Brindley with canals, of Smeaton with lighthouses, of Rennie with bridges, of Telford with nearly all these, of Fulton with steam-navigation, will remain matters of grateful remembrance as long as commerce itself shall exist. Harrison might, perhaps, scarcely be deemed to belong to this list, since a chronometer is almost too minute and delicate a machine to come within the department of civil engineering; but the same energy and ingenuity were called for in his case as in the others.

Brindley's career afforded a striking example of the way in which such men often overcame difficulties that would at first sight appear almost insurmountable. His birth was lowly, and his education still more lowly than his birth. He was apprenticed at an early age to a millwright; and in due time set up in business on his own account, soon acquiring a reputation for much skill in his avocation. By degrees his sphere of usefulness extended, and he was employed in works of larger and larger magnitude—calling for powers somewhat beyond those generally necessary in mere millwork:—water-engines for draining coal-mines, water-wheels for mills and factories, flint-grinding mills for the potteries, &c.

A new career opened for him and for England, when Brindley was introduced to the Duke of Bridgewater. This remarkable nobleman having at Worsley, about seven miles from Manchester, a large estate abounding with coal, which had hitherto lain useless because of the expense of land-carriage, and being desirous to work these mines, perceived the necessity of constructing a canal from Worsley to Manchester. He consulted Brindley on the subject, and the latter, pronouncing the scheme practicable, at once undertook it. A part of his plan consisted in carrying a canal over rivers and many large and deep valleys; and as nothing of the kind had been before done in England, he had to devise the means of doing it. Most of the engineers of the day laughed at his schemes as chimerical; but he soon gave the best of all proofs that they were not so. During the progress of this great work (for it became one of greater magnitude than was originally intended) the Duke's funds were so exhausted that he limited his own personal expenditure to 400*l*. per annum; while Brindley and the workmen had only just sufficient to go on with. Yet with all the difficulties the two men never shrank, and the work was finished. From that time to the day of his death Brindley was constantly employed in great works, chiefly canals, which excited almost as much attention fifty years ago as railroads do now.

Mr. Hughes, in a memoir of Brindley, says:—"In taking a hasty retrospect of Brindley's engineering career, it is important to observe, that all the works he projected, planned, and executed, are comprised within a period of twelve years, and by far the greater part of them within the last seven years of his life. It is amazing to reflect, that the man who had to struggle, without precedent or experience to guide him, with all the difficulties which attended the early history of canals, should himself have effected and originated so much. There can be no doubt that he possessed an intellect of the highest order, that his views were most comprehensive, and his inventive faculties extremely fertile. Brindley was wholly without education, and it has even been asserted that he was unable to read and write, the utmost extent of his capacity in the latter accomplishment extending no further than that of signing his name. This, however, has been disputed, on the authority of his brother-in-law, who stated that he could both read and write, though he was a poor scribe. However this may be, it was certain that he was quite ignorant, in the vulgar sense of the word, of education, and perfectly unacquainted with the literature of his own or any other country." Another author, in relation to Brindley's personal character, says:—"He never indulged or relaxed himself in the common diversions of life, not having the least relish for them; and though once prevailed on to see a play in London, yet he declared that he would on no account be present at another, because it so disturbed his ideas for several days after as to render him unfit for business. When any extraordinary difficulty occurred to him in the execution of his works, he generally retired to bed, and lay there one, two, or three days, till he had surmounted it. He then got up and executed his design without any drawing or model, for he had a prodigious memory, and carried everything in his head."

Smeaton, in like manner, was a man who had to strike out for himself the means of overcoming engineering difficulties which had baffled other men. But there was a wide difference between him and Brindley in this respect: Smeaton received a fair average education, and was well acquainted by reading with what had been done before his time. His father, who was an attorney, wished the son to follow the same profession; but young Smeaton showed a much greater fondness for miniature windmills, pumps, tools, and lathes, than for deeds and indentures; and the father judiciously allowed him to follow the bent of his genius. Smeaton made two long voyages, on purpose to test a new ship's log and a new compass which he had invented. He soon became known to the Royal Society by the scientific nature of his investigations into the powers of windmills and water-wheels.

The Eddystone Lighthouse was the greatest of Smeaton's works. On the dangerous Eddystone rock (as we shall explain further on) two lighthouses had been in succession built and destroyed; and, in 1756, Smeaton was employed to construct one which should brave both wind and wave. Most effectually did he effect his difficult task; for the Eddystone Lighthouse remains to this day apparently as strong and immoveable as the rock on which it is built. As nothing of so peculiar a character had before been constructed in England, Smeaton had to devise modes of effecting it; and year after year, from 1756 to 1759, his patience was sadly tried by the numerous difficulties which beset him. The nature of the difficulties which a lighthouse-builder has to contend against has in no case been more remarkable than in the instance of the Bell-Rock Lighthouse, constructed by Mr. Stevenson in the early part of the present century. The Bell-Rock is a very dangerous spot off the east coast of Scotland; and it was determined, in 1800, to have a lighthouse there. The rock being visible only at low water, and twelve feet under the surface of the water at high tides, the task of constructing a building on it was one of immense difficulty. The first undertaking was to construct on the rock a temporary residence, consisting of a room for the engineer, another for the foreman, a kitchen and provision store, and a sleeping-room for thirty men: this occupied them one season, for they could only work at the rock during low tide of each day, and had to go to and from a moored ship in open boats to each day's work. During the winter the masonry was prepared on shore; and in the ensuing summer a foundation was dug on the rock, and four courses of masonry laid: this was all that could be done in the very small number of hours during which the tide was sufficiently low, and the weather sufficiently calm and dry. During the third season the lighthouse could only be raised to a height of thirty feet, but the fourth season sufficed for its completion.

Such are some of the difficulties which engineers have to contend against; and if we were to trace the histories of our great engineers one by one, we should find that every department of this avocation is likely to be beset by some such obstacles. When Telford, for example, was employed to construct a good mail-coach road from London to Holyhead, he found the Menai Straits in his way, and had no resource but to boldly span the gulf by a bridge which should require no piers whatever in the watery valley below: thus arose a suspension-bridge, which has since served as a model to many others in different parts of the world. When Brunel undertook to make a tunnel under the Thames at Rotherhithe, although he most probably laid his account with meeting much that would task his ingenuity, he could hardly have imagined the trying embarrassments to which he was subjected in the course of his proceedings: what with the water flowing in and the money flowing out, he had enough certainly to tax his patience and his ingenuity.

With respect to Watt—in some respects the greatest of all engineers, in relation to the practical value of his labours—the kind of research in which he was engaged did not call so much for modes of contending against difficulties, as for the application of scientific principles to produce known mechanical effects. Brindley had infinitely more difficulties to contend against than Watt, but Watt's labours were more generally and extensively useful than Brindley's. However, any depreciation of one at the expense of another is an irksome task when such valuable men are concerned; and it is much more in accordance with justice to point to the eminence of each in the particular department which he took up, and to deem them alike worthy of the admiration of the world which they have benefited.

In taking a rapid review of some of the departments of civil engineering, it is important to bear in mind that the *mechanical* processes involved in such works are in fact such as have already occupied our attention: such as brickmaking and bricklaying; stone-working and masonry; carpentry; the preparation and manufacture of iron, &c. The office of the civil engineer is rather to combine the labours of many artificers, and put them in the right direction, than to strike out any new department of mechanical art. The details of this chapter, therefore, will relate chiefly to the peculiar features presented by the combination of those different arts in the chief kinds of engineering.

BRIDGES: THEIR CONSTRUCTION AND MATERIALS.

A bridge is one of the most useful results of engineering skill. We find examples of these structures in almost every country; and the remains of antiquity yet standing exhibit many specimens of bridge-building which show considerable ingenuity.

Rude forms of Bridges.

The natives of half-civilized countries have found means to construct rude bridges of many different kinds of material. Among these, *rope* is one that has been found to render much service. These are much used in South America, and are so much like suspension-bridges in some of their features, as to have given rise to an idea that they were really the models followed in the more modern and perfect structures: but this may very reasonably be doubted.

In many parts of Peru there are indications that the early inhabitants of that country paid great attention to the construction of roads, and the means of crossing fissures and valleys in the mountain districts. Fissures a few yards in breadth were passed by bridges formed of beams laid horizontally; but deep ravines or the channels of rivers were crossed in a different way. A suspension-bridge was formed of half-a-dozen cables of twisted osiers, passed over wooden supports, and stretched from bank to bank; then bound together with smaller ropes, and covered with bamboos. Humboldt passed over one of these pendulous bridges, of a hundred and twenty feet span (Fig. 1266); and Mr. Miers speaks of one which he crossed having a span of two hundred and twenty-five feet, over which laden animals might travel. It has been remarked as a singular circumstance, and one tending to support a theory which has been advanced respecting the early identity, or at least intercourse, of the Peruvians and the Chinese, that both nations have suspension-bridges, that some of their bridges are in both countries made of ropes, and that these ropes are in both countries made frequently of osiers.

Some of the South American bridges, known by the name of *bujaco*, are very narrow; and from this circumstance, and their great lightness, they oscillate in a very perilous manner. The width of these bridges is frequently only four feet and a half. One of them (if it deserve the name of a bridge) consists simply of a single rush-rope, on which a kind of carriage is swung, and drawn from one side of the river to the other by another rope attached to it, and held by a person on the bank.

Captain Basil Hall describes a rope-bridge in Chile, formed of six ropes, three on each side of the roadway. The ropes are firmly secured to the rock on the highest bank of the river, and are carried over a timber-frame on the opposite bank, where they are fastened either to trees or to stout posts driven into the ground. Short vertical cords are suspended from the main ropes, to carry the horizontal ones, on which the transverse planking of the roadway is laid. The span is a hundred and twenty-three feet; and the ropes being of hide, their elasticity causes such an undulation that travellers usually dismount and drive their mules over before them. This bridge was the scene of a somewhat perilous adventure during the South American war of Independence. A body of troops having to cross the river, the infantry passed over the bridge without the smallest difficulty, as did also the cavalry, each man leading his horse. When the artillery came up, doubts were entertained as to the possibility of getting it over. One of the officers volunteered to conduct the first gun. The limber was taken off, and drag-ropes attached to the carriage, by which the piece was to be restrained from descending the curved roadway too rapidly, while the trail was held up by two gunners; but, notwithstanding these precautions, the bridge swung so much from side to side, that the men lost their balance, and the gun was overturned. The carriage, by becoming entangled in the side parapet of thongs, saved it from falling into the river, but caused the roadway to tilt over so much, that every one on it was obliged to cling to whatever he could catch hold of, to save himself from dropping off into the foaming torrent sixty feet beneath. None dared, for some time, to venture to the relief of the party, expecting the bridge would break down every instant, especially if loaded with any additional weight; when, however, it was seen that nothing material gave way, two or three men crept along it to render assistance. The gun was with difficulty dismounted, the carriage taken to pieces, and so conveyed to the banks.

In India and Tibet the construction of rope-bridges and others of a like kind is very customary, especially in the mountainous districts between China and Hindostan. Mr. Frazer describes several of these, which he crossed during a tour among the snowy peaks of the Himalaya range. Many of them consisted of a single rope, stretched over posts on the banks; a kind of wooden saddle is made to slide on the ropes, over which loops are hung for the passenger to seat himself in, and he is hauled across by a line attached to the saddle. Captain Turner, in 1783, crossed a mountain defile in Bootan, by means of a bridge consisting of two ropes, made of the twisted stems of creeping plants, stretched across the chasm, parallel to and near each other; they were encircled by a hoop, in which the traveller sat himself, and holding one of the ropes in each hand, worked himself across.

From the same writer we learn that the natives of Bootan show great ingenuity in the construction of bridges adapted to the irregular surface of their country. The contrivance just described can hardly be designated a bridge; but where circumstances admit of it, bridges of various kinds are formed. They are generally made of timber, and if the width of the river will admit, they are laid horizontally from rock to rock. Over broader streams, a triple or quadruple row of timbers, one row projecting over the other, and inserted into the rock, sustain two sloping sides, which are united by a horizontal platform; the centre is thus raised very much above the current, and the whole bridge forms nearly three sides of an octagon. Piers are very seldom used, on account of the unequal heights of the banks and the extreme rapidity of the rivers. The widest river of Bootan has an iron bridge, consisting of a number of iron chains, which support a matted platform; and two chains are stretched above, parallel to the sides, to support a matted border, which is absolutely necessary to the safety of the passenger, who is not quite at his ease till he has landed from this swinging unsteady footing. At another place, a bridge for foot passengers is formed of two parallel chains, round which creepers are loosely twisted, from which suitable planks are suspended, the end of one plank resting upon the end of the other, without being confined.

The very elevated form here described as being sometimes given to the bridges of Bootan meets with a singular countertype in some of the Chinese bridges (Fig. 1269), the roadway of which is so elevated that we may also marvel how passengers can cross them.

The "natural bridges" which exist in many parts of the world, especially in America, might serve to give the first germ of an idea how to construct a stone bridge of arches, by observing how a few stones may be made to support each other, if they happen to join against each other in their fall through a narrow chasm. Many of the clefts or enormously deep fissures among the Andes are crossed in this way. At Icononza, for instance, there is a remarkable bridge of this kind. This is a cleft through which the river of Jumma Paz descends. The rocks consist of two different kinds of sandstone, the one extremely compact, and the other of a slaty texture, divided into thin horizontal strata. The fissure was probably caused by an earthquake, which the harder portion of the stony mass had resisted, and now connects the upper part of the chasm. This natural arch is fifty feet long, forty broad, and eight feet thick at the middle. Its height is about three hundred feet above the surface of the torrent, which has a medium depth of twenty feet. About sixty feet below the natural bridge another smaller arch occurs, composed of three slanting blocks of stone wedged together, which had probably fallen from the roof at the same instant of time, and struck against the sides of the crevice in their descent. There is another bridge, too, in a more northern part of the same continent, exhibiting nearly similar features, and formed in all probability much in the same manner: this is the Natural Bridge of Virginia (Fig. 1252). The severed rock consists of pure limestone, leaving a chasm about ninety feet wide, of which the walls are two hundred and thirty feet high, enriched with gay flowers and verdant herbage: the bridge, viewed from a short distance below, has much the appearance of a Gothic arch; and it is of such solidity that laden waggons used formerly to pass over it.

Bridges constructed by the Romans.

The remains of bridges constructed by the Romans are numerous and varied; but they must have been preceded by structures much more simple in their nature in those countries which had attained a far lower stage of civilization. It has been well remarked that, in respect to such matters, "men in the earliest ages would do as our villagers do at present: the accidents of nature would present a model; a fallen tree in a wave-worn cavern would frequently form a natural bridge, and the first bridges were composed of lintels of stone or wood, either of length sufficient to stretch from bank to bank, or, when this was impracticable, supported by piers or posts placed in the bed of the river. There are still considerable structures of this kind in China, and many of them in this country on a rural scale. This method, however, would in many situations be opposed by insuperable difficulties: the frequent piers required for the support of lintels would, by contracting the water-way, increase a strong current to a dangerously rapid torrent, impeding navigation, and undermining and destroying the piers themselves. It would, therefore, be found necessary in constructing bridges over rapid rivers, to have the supports as few and distant, and the openings as wide as possible; this could only be effected by the use of arches of stone and trusses of wood; accordingly these inventions must have been completed before bridges of importance had become common."

It is still a disputed point by whom and at what period the arch was invented; but the earliest regular arched bridges of which there are distinct records appear to have been constructed by the Romans. They had piers, arches, abutments, a carriage-way for vehicles, and a side-way for foot passengers—very much in the same way as modern stone bridges. There were eight bridges over the Tiber in ancient Rome; of which the first was originally constructed of wood, but was afterwards rebuilt of stone. One of the most noted of the Roman bridges was that which was built by Trajan over the Danube. It was erected as a means whereby succours could be sent to the Roman legions on the other side of the Danube. Subsequently, however, the bridge was destroyed by the Emperor Hadrian for an opposite reason; lest the barbarians, overpowering the guards set to defend the bridge, should by means of it pour into the provinces westward of the Danube. Some of the piers of the bridge are still visible in the middle of the river, near the town of Warbel in Hungary. If the account handed down by some of the early writers be correct, this bridge must have been a stupendous structure. According to this account, the bridge consisted of twenty piers of squared stone, each of them a hundred and fifty feet high above the foundation, sixty feet in breadth, and a hundred and seventy feet apart, which was the span or width of the arches; so that the whole length of the bridge was nearly fifteen hundred yards.

Another fine specimen of Roman skill in this department of engineering was the bridge at Narni, on the road from Loretto to Rome, of which a few fragments are yet to be seen. This bridge joined the mountains between which flows the river Nera; and it was built by Augustus to enable the inhabitants of Narni to pass from one mountain to the other. The arches were from eighty to a hundred and thirty feet span, and the loftiest of them was upwards of a hundred feet in height.

The Pont St. Esprit, near Lyons, is a bold example of Roman bridge-building. Its length is upwards of eight hundred yards; it is very crooked, bending and making several unequal angles, especially in those parts where the Rhône has the strongest current. The arches are about a hundred feet wide, and have their feet, in the bottoms of the piers, protected by two pedestals which project from them. Between the great arches there are smaller arches like windows, that come down nearly to the top of the pedestals, about the middle of the pier. This mode of construction was adopted with a view of breaking gradually the mighty force of the Rhône.

A very remarkable bridge, built by the Romans, was constructed, at the direction of Cæsar, over the Rhine. It was built with a double row of piles, inclining to the course of the stream, and joined together at distances of ten feet apart. Forty feet apart from these was another similar row, inclined against the stream. Large beams, two feet thick, were fixed between the piles, and held fast at the ends by two braces: these beams were joined by transverse pieces. The first double row of piles was protected by other piles beyond them, which served as buttresses, and were designed to protect the piles from timber floating down the stream.

Many of the other bridges were intended to serve the double purpose of aqueducts and bridges. The nature and object of aqueducts were explained in the Second Chapter; and it need only be stated here, therefore, that some of these structures had two or even three tiers of arches, one above another, the object of one being to serve as an aqueduct, and of another to serve as a bridge. A fine example of this construction is the "Pont du Gard," in the south of France, constructed by the Romans over the river Gard at Nismes. There is, in the first instance, a row of six arches, the united length of which is somewhat under five hundred feet; above these is a second series of arches, extending to a length of nearly eight hundred feet; and above these again is a third series, consisting of thirty-five smaller arches. The entire height of the whole triple tier is a hundred and ninety feet, and the uppermost channel or story serves as an aqueduct.

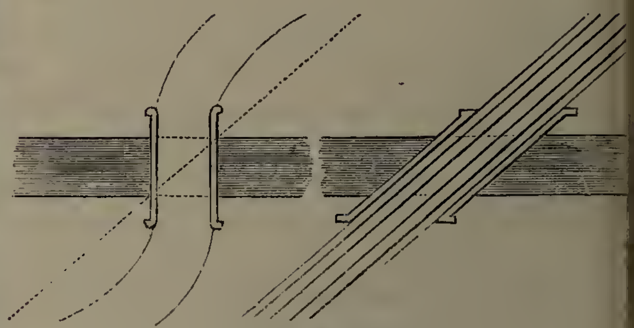
Modern Stone Bridges.

If we glance at the successive pages of woodcuts in the early part of this Chapter, we shall see how varied are the forms which have been given to stone bridges in different places and at different times. From almost absolute plainness, to a profusion of decoration; from a perfectly level roadway, to one which rises very steeply towards the centre; from a multiplicity of small arches, to a more limited number of arches of great magnitude; from a length sufficient only to cross a mere rivulet, to a length that will span a mighty river—all are to be found among the numerous stone bridges which our and other countries present.

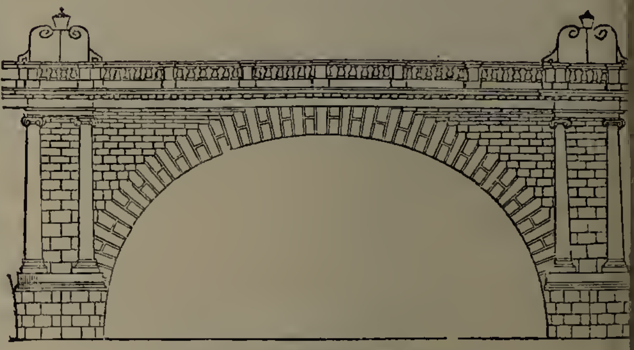
The "Rialto," or chief bridge of Venice (Fig. 1256), is a good example of the more decorative kinds of bridges. The city of Venice is so completely intersected by canals, that five hundred bridges are necessary to afford communication from one part of the city to the other. Of these five hundred, the Rialto is the principal. A wooden bridge occupied its site until about two centuries and a half ago, but at that period the present one was constructed. It consists of one bold arch of nearly a hundred feet span, and only twenty-three feet above the water-level. It is forty-three feet in width, and has two rows of shops running

1274.—Coffer-dam, used during the repairs of Blackfriars Bridge.

1275.—Pressure of an Arch.



1276.—Skew-bridge.

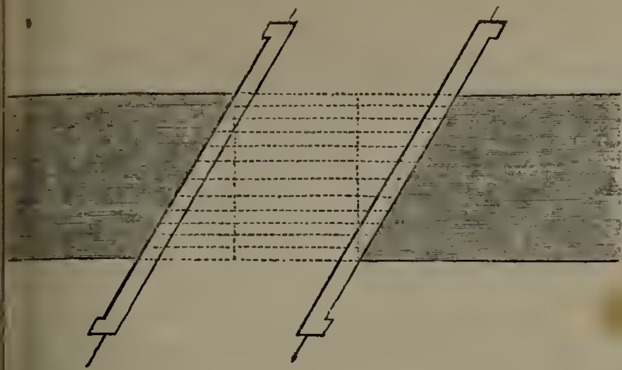


1277.—Arch of Blackfriars Bridge.

1278.—Mode of repairing Blackfriars Bridge.

1279.—Blackfriars Bridge, in 1842.

1280.—Iron Bridge, Colebrook Dale.



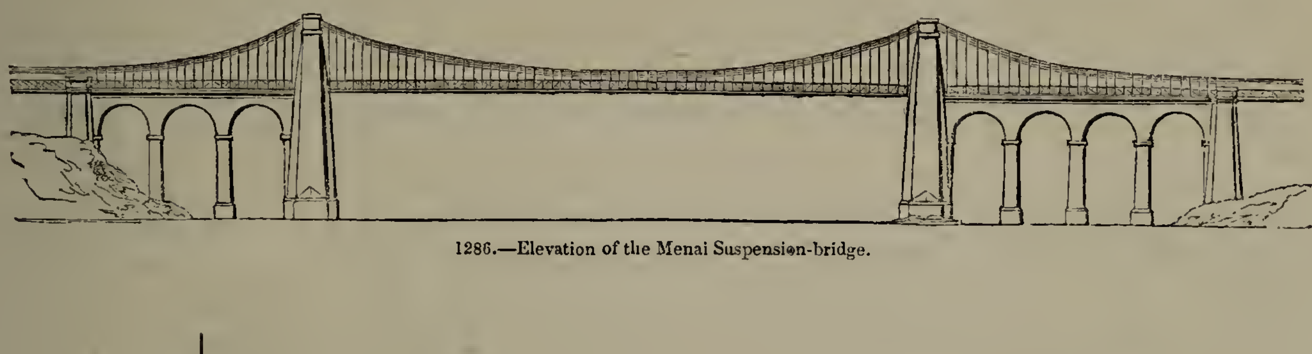
1281.—Skew-bridge.

1282.—Skew-bridge.

1283.—Building of Westminster Bridge. (From a Picture by Canaletti.)

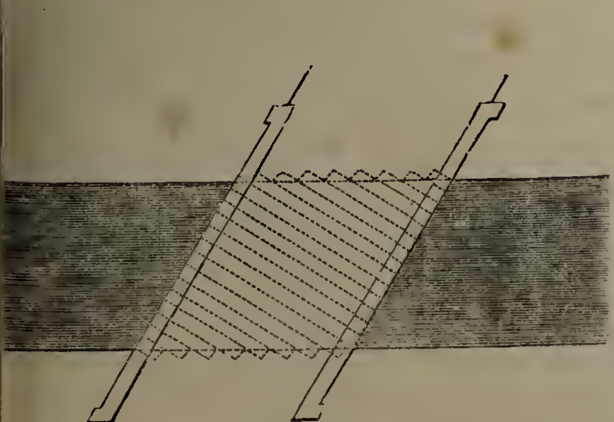
1284.—Waterloo Bridge.

1285.—Vauxhall Bridge.



1286.—Elevation of the Menai Suspension-bridge.

1287.—Cross-section of the Fribourg Bridge.



1288.—Skew-bridge.

1289.—Westminster Bridge, in 1842.

along its roadway from end to end, so that there are three streets or avenues along the bridge. The whole of the exterior of the bridge, and of the shops upon it, is constructed of marble. Access is gained to the level of the roadway from the water by an ascent of fifty-six steps at each end.

Different forms of stone bridges are shown in Figs. 1253, 1254, 1255; but some of the finest in existence cross the Thames at London; and it will suffice for our purpose to say a few words concerning these.

A century ago there was only one bridge across the Thames within the precincts of the metropolis: now there are seven; or, if we include Chelsea in the metropolis, there are eight. Old London Bridge was in every respect among the most remarkable in the country. Whether there was any bridge at London in the time of the Romans is a disputed point; nor is there any distinct record of one until about the year A.D. 1000, at which time there was a bridge wide enough for two carriages to pass each other. Within a period of two centuries, this bridge, which was most probably of wood, appears to have been destroyed and rebuilt several times; and it was not till about the year 1200 that a stone bridge was actually built on the spot. The cost of its construction was defrayed by a tax upon wool. The bridge consisted of twenty arches, supported upon nineteen piers, the roadway being rather less than a thousand feet in length, sixty feet in height from the river, and forty feet wide.

One of the peculiarities of this bridge was, that houses were erected on it as thickly as they could stand, so as greatly to limit the passenger-room. If we look at the view sketched in Fig. 1259, we see what a mass of houses the bridge presented in 1616; and this mass appears to have been in nowise diminished in 1760 (Fig. 1261). There was a chapel too; and at the end of the bridge was a tower on which the heads of decapitated criminals were stuck upon poles. The buildings were so close together that the roadway varied only from twelve to twenty feet in width; and sometimes the goods on heavily-laden waggons were entangled in the beams of the projecting first floors of the houses. On one of the piers of the bridge was built the oddly-shaped structure sketched in Fig. 1262, which was first a chapel and then a paper-warehouse.

From time to time complaints were made against the old bridge, as being inconvenient for the traffic of a great city; but corporations usually move slowly in such matters. In 1685, by the removal of some of the houses, the roadway was widened uniformly to twenty feet. In 1697 the approach at the south end was widened. About 1760 the whole of the houses were pulled down; and the bridge then presented, for a period of about seventy years, the appearance shown in Fig. 1264. Repairs and patchings-up went on from time to time, until at length it was resolved to build a new bridge altogether.

The new bridge was planned by the late George Rennie, but constructed by his son, the present Sir John. The first pile of the coffer-dams was driven in March, 1824; the first stone was laid in June, 1825; and the new bridge was opened in August, 1831 (Fig. 1265). The cost of the bridge, together with the north and south approaches, was little short of two millions sterling.

The relative position of the two bridges is shown by the plan in Fig. 1270, where the uppermost shows the old bridge and the lowermost the new, together with the new openings and approaches made at the ends. The irregularly-shaped oval pieces observable in the old bridge were the "starlings," or "sterlings," constructed as a means of preserving the piers from injury. The bridge had nineteen narrow arches, very irregular in width; and the massive piers which separated these caused such a formidable obstruction to the free flow of the river, that a dangerous eddy existed at the spot. Indeed it was partly with a view of remedying this eddy that the new bridge was constructed, and this object has been very efficiently attained.

New London Bridge (Figs. 1263, 1271) consists of five semi-elliptical arches, the smallest of which is said to be larger than any other stone arch of this form ever erected. The centre one is about a hundred and fifty feet wide, with a rise of only thirty; the two next the centre are a hundred and forty each; and the two outer ones a hundred and thirty each. The roadway is upwards of fifty feet wide. The extreme length is about nine hundred and thirty. The whole bridge is built of granite, of which the enormous quantity of a hundred and twenty thousand tons was used. The bridge is on so superior a level to that of the old bridge, that it crosses the water-side streets on either bank by means of dry arches, at a considerable elevation. In Fig. 1260, for instance, we see the dry arch by which the bridge is carried over Thames Street.

The next stone bridge, higher up the river, is one which has been full of misfortunes, in respect to the frequent repairs required by it. Blackfriars Bridge was built in conformity with an Act of Parliament passed in 1756. The engineer selected was a hitherto unknown man named Mylne, who planned a bridge consisting of nine elliptical arches, the centre one a hundred feet wide, and the others diminishing gradually till the end ones were about seventy feet wide each. A furious paper war was carried on for some time as to the feasibility of Mylne's plan, but he was permitted to work it out pretty much in his own way. Piles were driven into the bed of the river to support the piers, and the piers themselves were built by means of *caissons* (of which, as distinguished from *coffer-dams*, we shall speak presently). The work proceeded amid many difficulties, and the bridge was opened for vehicles in 1769. The cost was about 300,000*l.*, which was in the first instance proposed to be paid for by a toll; but the government subsequently purchased the bridge, and threw it open freely to the public.

Blackfriars Bridge (Figs. 1273, 1279) consists of nine elliptical arches, of which the general figure is shown in Fig. 1277. On the cutwaters or supports of the piers are two Ionic columns supporting an entablature, on which is a platform forming a projecting recess, which with the entablature of the column is carried along the whole extent of the bridge. The roadway, as originally formed, was very steep, having an inclination of one foot in sixteen; but this has been since greatly improved.

Unfortunately, the stone of which this bridge was built is of a very soft and rotten character; so that the talents of the engineer were in great measure thrown away on an ungrateful material. The repairs which have been called for by Blackfriars Bridge have been both frequent and expensive. The stone (Portland stone) is so unable to resist water, that it crumbles away beneath and at the water level; and after repeated attempts to patch up the old structure, it was resolved in 1833 to spend about a hundred thousand pounds in thoroughly repairing the foundations of the piers, by means of new piling, new cutwaters, new arch-stones. The "cutwaters" here alluded to are the angular projections at the piers; designated, as the name imports, to "cut" the water, or cause it to glide off into the arches on either side, without butting in full force against the pier itself. In repairing the piers, the foundations were rendered secure by a casing of sheet-piling covered with granite masonry. The "cutwaters" were built up to a greater height than they had been before, and were repaired by new stones where required. In Fig. 1272, for instance, there is given a plan of one of the cutwaters; the light parts representing new stones introduced into the old structure. The coffer-dams used in these repairs, and the curious mode of repairing the arches, we shall consider presently.

Westminster Bridge has not been more fortunate than Blackfriars, in respect to the material employed in the construction: indeed it has been the less satisfactory of the two. The history of this bridge is a curious exemplification of the narrow jealousy which so often retards commercial improvements. The Corporation of London were so terror-stricken at the idea of having a second bridge over the Thames, that from the time of Elizabeth to that of George II., whenever a proposal was made to construct a bridge at Westminster, all kinds of evil—to the river-navigation as well as to the citizens—were anticipated. At length, however, in 1736, an Act of Parliament for this purpose was obtained. It was proposed to raise the necessary funds by means of the profits derived by the government from a lottery—that very curious example of legislative cheating. About two hundred peers and commoners were formed into a "Bridge Commission," and an amazing deal of parade was made about the matter. These commissioners selected as their engineer Mr. Labelye, a native of Switzerland, who thereupon entered with much energy on his difficult undertaking.

The width of the river at Westminster Bridge is three hundred feet greater than at London Bridge; and the number of piers and arches required was consequently large. The first stone of the first pier was laid in 1739, and considerable progress was made in that year; but the severe frost of the ensuing winter undid nearly all that had been done, by hurling huge masses of ice against the piles. It had been intended to build a superstructure of timber; but on recommencing operations, a stone bridge of fifteen arches was decided on. Amidst many and trying difficulties Labelye proceeded with his work; and in November, 1750, he had the satisfaction of seeing the bridge opened in great state. In Fig. 1283 we have a view of the bridge while in the course of construction, from a picture by Canaletti; in Fig. 1289 the bridge is shown as at present existing. Of the peculiarities in this bridge (peculiar in those days) Labelye, in a history of the work, says that above 50,000*l.* worth of stone and other materials are always under the ground or concealed by the water; that each of five arches is wider than the largest hall in Europe; that the quantity of stone in the middle arch only, above the piers, and exclusive of all its ornaments, is full five hundred tons more than was used in the Banqueting House, Whitehall; and that the whole bridge contains nearly double the quantity of stone materials to those employed in the erection of St. Paul's. Most persons passing over this bridge must have observed the recesses on either side; of these it has been stated that "so just are the proportions, and so complete and uniform the symmetry, that, if a person whispers against the wall of the alcove on one side of the way, he may be plainly heard on the opposite side; and persons may converse without being prevented by the interruption of the street or the noise of the carriages."

Of the almost unceasing repairs which the arches and piers of this bridge have required, the proposals for rebuilding or greatly modifying it, and the connexion of the bridge with the suggested "Thames Embankment" scheme, most newspaper readers are pretty well aware.

Waterloo Bridge, another of the metropolitan bridges, is distinguished from all the others as being quite flat or level. Of this bridge it has been observed by a writer in 'London' (No. 61), that when we gaze on this "exquisite combination of all that is most valuable in bridge architecture with all that is most beautiful—the broad and level roadway, and the light and elegant balustrade, the almost indestructible foundations, and the airy sweep of the arches they support—we feel the justice of Canova's opinion, that this is the finest bridge in Europe; and can appreciate the great artist's enthusiasm when he added that it was alone worth coming from Rome to London to see. And in Canova's words the opinion of professional men, English and foreign, as well as of the most enlightened connoisseur, has found voice."

This bridge (Fig. 1284) was built by Mr. Rennie. The first stone was laid in October, 1811; and the bridge was finished and opened in June, 1817. The whole structure is composed of Craigleith and Peterhead granite. The bridge consists of semi-elliptical arches, all of equal size, being a hundred and twenty feet span. Besides these stone arches over the river itself, there are long series of arches at each end to connect the bridge with the neighbouring streets; there are sixteen of these on the Strand side, and no less than thirty-nine on the Surrey side. The bridge itself is 1326 feet long, the abutments 54, and the land arches 1076; making an extreme length of 2456 feet, within a shade of half a mile. Waterloo Bridge cost more than a million sterling, and has been as unfortunate in a commercial point of view as it is admirable as a work of art; but we may perhaps hazard a conjecture that one of two things will occur before many years have elapsed—either that the bridge will be made toll-free by parliamentary purchase; or that it will be made a railway viaduct to connect the northern and southern systems of railways with each other. M. Dupin, in an eloquent passage, pictures to himself a traveller, in some future age, visiting England for the first time, and coming in sight of Waterloo Bridge. What are his thoughts at the moment?—"The traveller, on beholding this superb monument, will suppose that some great prince wished, by many years of labour, to consecrate for ever the glory of his life by this imposing structure; but if tradition instruct the traveller that six years sufficed for the undertaking and finishing this work—if he learns that an association of a number of private individuals was rich enough to defray the expense of this colossal monument, worthy of Sesostris and the Cæsars—he will admire still more the nation in which similar undertakings could be the fruit of the efforts of a few obscure individuals, lost in the crowd of industrious citizens."

The Arch: the Caisson: the Coffer-dam.

Of all the parts of a bridge the *arch* is that to which its principal character is chiefly owing. The attainment of a sufficient roadway to admit of the passage of vehicles above, and the maintenance of a water-way sufficient to admit broad vessels, are objects which led to the selection of the arch as a most convenient form into which to place the materials employed.

We may take Fig. 1257 as an illustration of the mode in which stones or bricks may be made to support each other, and form an opening beneath them. This is not an arch, in the proper meaning of the term, but it is one in effect. On two side piers are built up two masses of masonry—not vertically, but inclining at such an angle as to meet at the top, where a "keystone" keeps all the others together. Hence the diagonal stones cannot fall unless the piers fall, or the key-stone gets out of its place. This "key-stone" is a most important part of every arch, since by its means the other stones are locked in their places. In Fig. 1275 there is an arch of the circular form shown; in which it will be observed that all the arch-stones are wider at the upper or outer part than at the lower or inner; and this is the circumstance which prevents the stones from falling out singly so long as the mass generally remains stable. As to the degree and kind of pressure to which the stones are exposed, some difference of opinion prevails among practical men. Dr. Robison supposed that the pressure is communicated from stone to stone in a straight line, in the manner shown by the lines in Fig. 1275.

Leaving theory out of the question, however, the construction of a large arch requires the aid of a very extensive system of timber framing, called the centreing. This framing is built up to the exact size, form,

and position of the arch, so as to present at the top a surface on which the stones of the arch are to be laid. When the whole of the stone-work of the arch is finished, the centreing or framing is removed, and the stones are then left to support each other, which they do by the curved form given to them. In the modern bridges the accuracy of workmanship is so wonderful, that the superstructure scarcely sinks at all when the centreing is knocked away, but preserves almost exactly the form which the centreing had given to it.

In the repairs of Blackfriars Bridge, completed a few years ago, a very curious mode was adopted of letting in new stones in the arches, without disturbing the general stability of the structure. As the stones of an arch are smaller at the inner curved surface than at the opposite surface, considerable difficulty was found in replacing bad stones with new ones; but success was attained by the adoption of a principle similar to that whereby boot-trees are built up of two or three pieces. The method is thus described in the Penny Cyclopædia: —

"The broken or decayed parts of the arch-stones are generally cut out to the depth of fifteen inches. After the old work has been properly prepared, the space is filled up with two stones or thicknesses instead of one. The one first laid, which we will call the lower stone, is thicker at the back than at the front by rather more than the difference of the heights of the front and back part of the whole course of which it is a part. Suppose the course to be fitted in is two feet five inches high in front, and two feet six inches at the back; the lower stone is made one foot five inches high on the face, and one foot six and a half inches at the back. The other stone will then require to be thinner behind than before, and in the case supposed will be twelve inches in front and eleven and a half behind; or, in other words, it is a stone wedge fifteen inches deep, with a draught of half an inch, which, when driven back, causes the two thicknesses to take a bearing with the old work. In the centre of the bed of this upper stone a hole is bored, into which, previous to its being driven, is put a circular stone plug, tapering from the middle towards each end; to this plug a cord is attached, which passes through a hole drilled from the chamber outside to the upper part of the large hole, where it is fastened to the top of the stone plug. By this means the plug is kept steady during the operation of driving. When the upper stone has been driven into its place, the cord is loosened, and the plug falls half its length into a hole, which has been made to receive it, in the lower stone." When the stone which is to be replaced is high up in the arch, near the key-stone, it requires an extra string to aid in keeping the plug in its proper position for entering the holes. Fig. 1278 will give an idea of this singular contrivance. One stone, B, is represented as having been adjusted to its place; another, A, is in the act of being adjusted. 1 is the wedge-stone, 3 is the other stone, *a* is the plug, 4 is the hole to receive the other half of the plug, 2 is one end of the string, and 5 is the other, where there is a handle to manage it by.

Another interesting feature in bridge-building is the determination of the mode by which the operations are to be conducted under water. As there is a great mass of masonry below the level of the water, and an extensive system of piling to support this masonry, some mode must obviously be devised of keeping out the water while the workmen are occupied in these submarine works. Two contrivances are adopted for this purpose: the *caisson* and the *coffer-dam*.

Labelye's method of constructing the piers of Westminster Bridge afforded the largest example ever seen in England of the use of the caisson. Caissons may be characterized as enormous boxes framed of wood, and rendered air-tight. According to the plan which Labelye gave to the Bridge Commissioners, he proposed that the foundation of every pier should be laid on a strong grating of timber planked underneath; that this grating of timber should be made the bottom of a *caisson;* that the sides of this caisson should be so contrived as to be taken away after the pier was finished; that the bed of the river should be dug to a sufficient depth and made level, in order to lay thereon the bottom of the caisson; that wherever the ground under the excavation or pit should prove good, there would be no necessity for piling it; but that, in case the ground under the foundation of it should not prove of a sufficient consistence, it should be sawn level, close to the bottom of the pit; and on their tops the grating and foundation of the pier should be laid. The general outline of this plan was acted on. The caissons employed were enormously large, each one containing a hundred and fifty loads of fir timber. The length of each caisson was eighty feet, the breadth thirty, and the depth ten. Mylne also adopted the use of caissons in the building of Blackfriars Bridge. The principle in the construction of these ponderous wooden vessels is to drive in a small number of piles round the spot where the pier is to be situated; to construct a water-tight timber vessel of immense magnitude and strength, open at top but closed in every other part; to float this machine to the spot, and get it within side the framework of piling; to load it with masonry, built on the bottom, until it is heavy enough to sink to the bottom: to build up the whole of the pier on this bottom, as it lies flat on the bed of the river on the heads of the sunken piles; and then to knock away the sides of the caisson, leaving the entire pier resting on what had been the bottom of the caisson. This principle, however, is not much adopted by modern engineers, for a reason that has been thus stated:—"The wooden platform, with the pier upon it, being dropped as it were by chance into the stream, is likely to find an irregular foundation; and whenever this happens to be the case, currents and springs are sure to insinuate themselves beneath, and unsettle the whole superstructure. Besides, wooden foundations are only safe as long as they can be kept completely immersed in water; so that, as often as a very low ebb takes place, there is a risk of air gaining access to the timber and implanting the seeds of speedy dissolution."

In the use of the *coffer-dam* the arrangement is somewhat different. The coffer-dam consists of piles, which are squared beams of wood pointed at one end and shod with iron, and surrounded at the top with an iron collar; these piles are driven into the bed of the river, and being braced together, form a wall of wood. The piles are sometimes grooved and tongued together; in other cases they are driven at short distances apart, and boards are let into the grooves formed down their sides. Two such inclosures are formed, one within the other; and the space between the two is filled with clay or chalk rammed down hard. The water in the inner inclosure is then pumped out, and there remains a vacant space in which the men can work safely, although there is water all around them. Sometimes coffer-dams have had to be constructed as much as forty-five feet deep; and where the current of the river is strong, two rows of piling are found hardly sufficient to keep out the water: three or four rows are constructed, and clay rammed hard between them all.

The coffer-dams used in the construction of London Bridge well illustrate the larger and more important of these contrivances. As the bed of the river at that spot is upwards of thirty feet in depth at low-water of spring-tides, and as the current was very rapid, it was found necessary to make the coffer-dams unusually strong, as a means of keeping out the water. The general form of the dam was elliptical. Three rows of piles, dressed in the joints and shod with iron, many of them measuring from eighty to ninety feet in length, were driven into the ground, and after being firmly bolted together, the interstices between them were filled up with clay. Wooden stays or props were introduced between the different rows of piles; and the whole of the interior space was strongly framed with timbers. Stairs were formed for descending into the coffer-dam, and pumps were fixed to raise the water arising from springs or leakage. So well, however, was the coffer-dam constructed, that hardly any water gained entrance into it. In building the pier, the lowermost course of masonry was laid on piles of beech driven in the interior of the coffer-dam to a depth of nearly twenty feet. A good idea of the interior appearance of these coffer-dams is given by Fig. 1274, which represents one of those used in the repairs of Blackfriars Bridge.

Bridges of Brick and of Timber.

The recent advancement of railways has led to a very increased use of brick in building bridges. The desire to save expense, and improvements in the art of brick-work, have brought about this result. The viaducts forming the Greenwich and Blackwall Railways may, so far as arched brick-work is concerned, be considered as bridges on a vast scale; and these form the largest series of well-constructed brick arches in England. The Manchester and Birmingham Railway, at Stockport, crosses the Mersey by a bridge or viaduct more than a hundred feet in height: it consists of twenty-six arches, of which twenty-two are of sixty-three feet span each; the extreme length of the structure is about eighteen hundred feet, its mean elevation ninety feet, and its width thirty-two feet: it consumed eleven million bricks and four hundred thousand cubic feet of stone! The Great Western Railway crosses the Thames at Maidenhead by a brick bridge, consisting of ten arches, of which the two principal are the largest and flattest brick arches ever built, being of a hundred and twenty-eight feet span: the other arches are much smaller, being intended merely to lighten the abutments. The Brighton Railway crosses the valley of the Ouse by a beautiful brick viaduct, consisting of thirty-seven brick arches of thirty-feet span; the length of the viaduct is about fourteen hundred feet, and the height varies from forty to a hundred.

A remarkable variety of bridge, developed mainly by the exigencies of the railway system, is the *skew* bridge, of which plans are sketched in Figs. 1276, 1281, 1282, 1288. This form of bridge is adopted when it is desirable to cross a river or a road obliquely, instead of at right angles, as is usually done. Before railways were introduced, the carrying of a canal or a road over a lower road or canal or river by means of a bridge was usually effected at right angles, as being easier and less expensive; but this often required a deviation in direction, as observable in the left hand of Fig. 1276. But in a railway this deviation could not be permitted, and hence the necessity of contriving skew or oblique bridges.

Brick is frequently the material employed for these arches. There is one of this kind on the Birmingham Railway near Boxmoor, with an arch of very oblique span. Other materials, however, such as stone, iron, and timber, are similarly employed; the main difference between them in this form of bridge and in the common bridge being in the curvature given to the pieces employed.

The use of *timber* as a material for bridges has been far more extensive than that of brick; indeed timber was the primitive material employed for this purpose.

One of the most remarkable bridges of this description was constructed on the Rhine in 1758 by a self-taught carpenter named Ulric Grubenman. The rapid current of the river at Schaffhausen having gradually undermined the piers of a stone bridge at that place, it fell down in 1754; and a plan was proposed to supply its place by one of timber, as requiring fewer piers, and therefore not being exposed to an equal degree of danger from violent currents. Grubenman offered a model of a bridge requiring no pier at all; but his design being considered too bold and chimerical, the authorities insisted on one pier of the old bridge, which was intentionally left standing, being used as an intermediate support. The design was accordingly modified, and Grubenman built the bridge, apparently in one span from shore to shore, but additional strength was given by beams springing from the old pier. The length of the bridge was three hundred and sixty-four feet, and its breadth eighteen. It was not in a straight line on the plan, but formed a very obtuse angle towards the current. The bridge was an inclosed gallery: the sides consisting of the framing of the complicated trusses necessary to support such an arch; and there was a roof over the roadway resting on the sides. This beautiful bridge was unfortunately destroyed by the French army during the campaign of 1799.

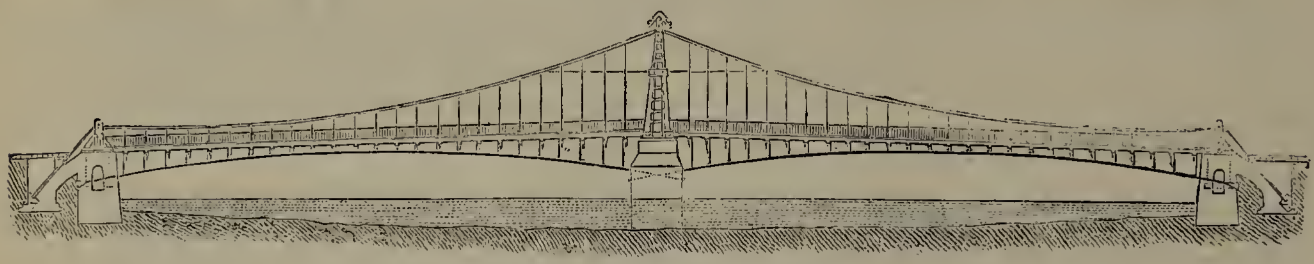
Other German builders designed and executed several fine specimens of timber bridges during the last century, among which was one with an exceedingly large span.

In America, too, owing partly to the abundance of timber, this material has been very extensively employed in the construction of bridges. There was one erected in 1794, with a span of two hundred and fifty feet; another over the Delaware, with a span of two hundred feet; and a third over the Schuylkill, with three arches, the centre one a hundred and ninety-five feet span, and the other two a hundred and fifty feet each. But the finest timber bridge in America is considered to be that which crosses the river last mentioned (the "Schuylkill") near Philadelphia. It is sketched in Fig. 1258, in such a way as to show both the external appearance and the internal mode of construction. This fine bridge presents an arch of three hundred and fifty feet span, with a rise of only twenty feet, and a depth of only seven feet at the centre. The arch consists of three equal and similar ribs, each composed of seven thicknesses of planks; each of these planks is thirteen inches wide by six inches thick, cut to the proper curve, and the joints are alternated like those of masonry, to ensure strength. Each rib carries a trussed frame, the two outer ones of which constitute the sides of the bridge; the roadways between are roofed over, and as the whole is planked externally, the bridge forms an enclosed gallery, lighted by numerous windows on each side. There is a lodge or portico at each end, so that the bridge presents, in every respect, a very remarkable appearance.

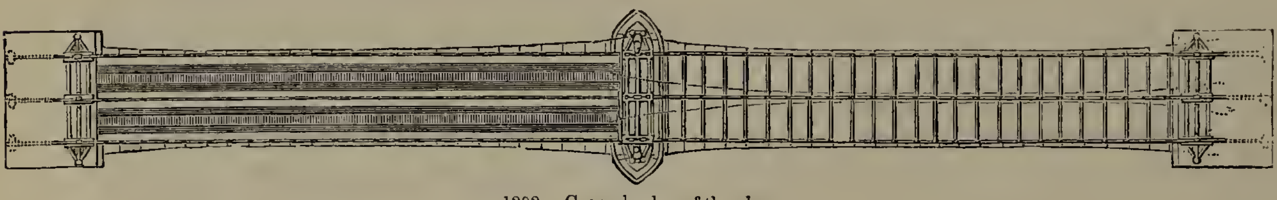
A kind of timber bridge is occasionally constructed in America, in which the roadway is supported by a series of latticed-like frames of timber, arranged in parallel vertical planes, and extending continuously from end to end of the bridge, simply resting upon the piers, which may safely be made slender and wide apart, because the construction of the lattice frame-work effectually prevents any lateral strain which might tend to overturn them. This mode of construction is adopted for viaducts intended to carry a railroad over a valley.

Timber viaducts have been adopted in some instances in English railways. The "Bricklayers' Arms" Branch of the Dover Railway is constructed of timber. The Birmingham and Derby Railway crosses the junction of the rivers Tame and Trent by a bridge composed entirely of timber, nearly thirteen hundred feet long, thirty-three feet high on an average, and twenty-nine feet wide. Two other railway viaducts are thus described in the 'Penny Cyclopædia:'—'The Willington Dean Viaduct, one of the extraordinary timber-arched bridges, erected by Mr. Green, for the Newcastle and North Shields Railway, consisting of seven arches, varying from one hundred and fifteen to one hundred and twenty-eight feet span, and of the mean height of seventy-three feet, and width of twenty-four feet, cost 24,000*l.*, or 7*s.* 1*d.* per cubic yard. The piers of this viaduct are of stone, and the arches consist of ribs formed of planks laid over each other, with the joints carefully broken, so as to form massive arcs,

1290.—Fribourg Suspension-bridge, Switzerland.

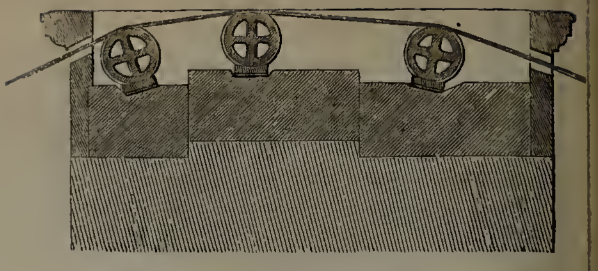


1291.—Suspension-bridge in the Isle of Bourbon.

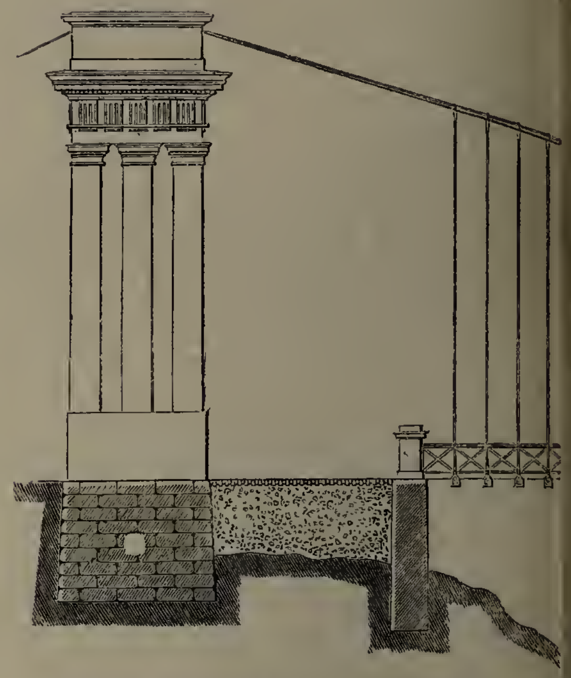


1292.—Ground-plan of the above.

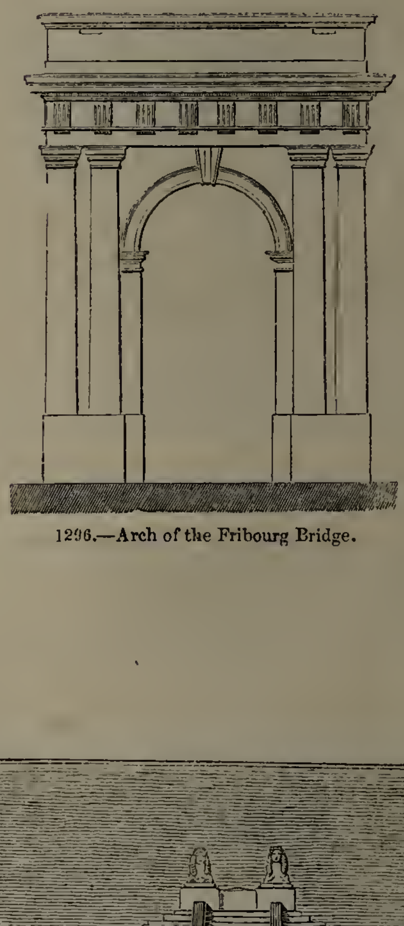
1293.—Menai Suspension-bridge, Anglesea.



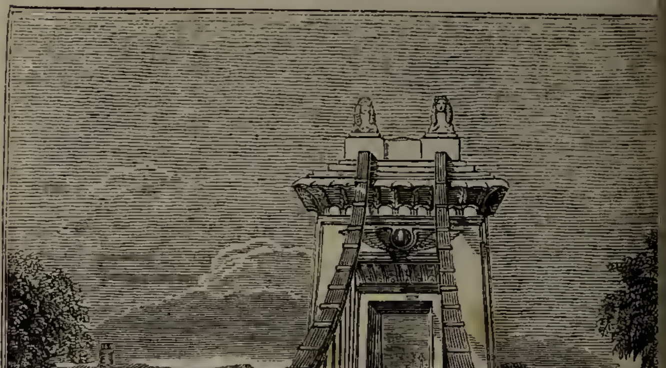
1294.—Rollers on the top of the Pier: Fribourg Bridge.



1295.—Sid of the Pier and Terrace: Fribourg Bridge.



1296.—Arch of the Fribourg Bridge.

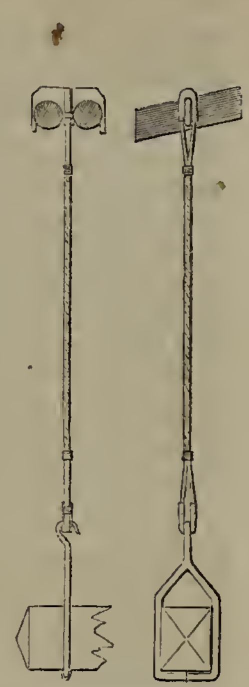


1297.—Design for the Gateways to the Suspension-bridge over the Avon, Clifton.

8.—Vertical Shaft of Fribourg Bridge.

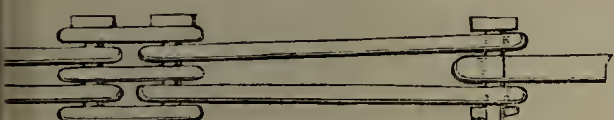
1299.—Proposed Suspension-bridge over the Avon at Clifton (partly constructed).

1300.—Suspension-bridge over the Dee at Aberdeen.



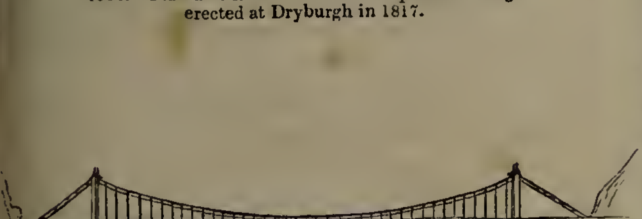
1302.—Suspending Cords of Fribourg Bridge.

1301.—Suspension-bridge over the South Esk, at Montrose.



1303.—Chains of Suspension-bridge.

1304.—Plan and Elevation of the Suspension-bridge erected at Dryburgh in 1817.



1305.—Suspension-bridge erected at Dryburgh in 1818.

1306.—Findhorn Suspension-bridge, in the North of Scotland.

each consisting of several laminæ of planks, and being far more solid than a solid piece of timber, supposing it had been possible to procure such of the requisite dimensions. A viaduct on the same principle has been very recently constructed over the river Etherow, for the Sheffield and Manchester Railway, consisting of three arches, of which the centre is one hundred and fifty feet span, while the western and eastern arches are one hundred and thirty-five and one hundred and twenty feet respectively. The arches are all of the same radius, in order to equalize the strain on the piers, and the versed sine of the centre arch is forty feet. Each arch consists of three ribs, five feet in depth, composed of three-inch planks, previously rendered impervious to dry-rot by immersion in a solution of sulphate of copper, and further secured from decay by the insertion of a layer of brown paper, dipped in tar, between each layer of planks. The centre ribs are two feet four inches wide, and those at the sides one foot ten inches each. The total height of this extraordinary bridge, from the foundation, is one hundred and thirty-six feet; its total length is five hundred and six feet; and its cost was about 25,000*l.*"

Bridges of Iron.

One of the recent notable consequences of the extension of the iron manufacture in this country is the employment of this metal in the construction of bridges. The first iron bridge built in England was erected in 1779 over the river Severn, at Coalbrook Dale; and was cast by Abraham Darley, at the great iron-works situated in that district. This bridge (Fig. 1280) consists of one arch upwards of a hundred feet wide, composed of five ribs, each rib formed of three concentric arcs, connected together by radiating pieces. The interior arc forms a complete semicircle, but the other arcs extend only to the sills under the roadway; these arcs pass through an upright frame of iron at each end, which serves as a guide, and the small space between the frame and the outer arc is filled with a ring about seven feet in diameter. On the top of the ribs cast-iron plates are laid to sustain the roadway.

Numerous iron bridges have been constructed since that time. One of these is a fine bridge over the Wear at Sunderland. This consists of an elegant arch two hundred and forty feet span, and elevated a hundred feet above the level of the water; so that vessels of three hundred tons burden can pass under it without striking their topsails. Another, built by Mr. Telford at Buildwas, in Shropshire, is remarkable for the mode in which the roadway is partly suspended and partly supported; but this mode of construction will be spoken of in connexion with "suspension" bridges.

The two iron bridges over the Thames at Vauxhall and Southwark are very fine specimens of the use of this metal in bridge-building: especially the latter. Vauxhall Bridge—originally named "Regent" Bridge, on account of the first stone having been laid by Lord Dundas, as Proxy for the Prince Regent—was planned and executed at the expense of a body of shareholders, who were opposed by the Corporation of London, as all the other modern bridge-builders on the Thames had been opposed, but with no greater success ultimately than in the other cases. Mr. Ralph Dodd, Sir J. Bentham, and Mr. Rennie, were all employed in succession in preparing the plans; but Mr. Walker was the engineer whose plans were finally adopted, and who carried them out. The work was commenced in May, 1811. In September, 1813, the first stone of the abutments on the Surrey side was laid by Prince Charles, son of the Duke of Brunswick. The entire work was finished in 1816, and was opened in the month of July in that year. Vauxhall Bridge (Fig. 1285) is considered to be the lightest structure of the kind in Europe. There are nine arches, all of equal span, being seventy-eight feet; supported on rusticated stone piers. The roadway measures thirty-six feet across, and the entire length of the bridge is eight hundred and nine feet. The expense was about 300,000*l.* The iron-work was cast at the Butterly Works in Derbyshire.

Southwark Bridge, considered in many respects to be the finest iron bridge in the world (Figs. 1267, 1268), was commenced about the same time as Vauxhall Bridge; and, like it, at the expense of a company of shareholders. But, although the Vauxhall Bridge proprietors have little to boast of in the shape of revenue, those of Southwark Bridge are far more luckless; for their bridge, costing 800,000*l.*, is far less used than Vauxhall Bridge, which cost little more than a third of the money. Of Southwark Bridge, indeed, it may be said, as of Waterloo Bridge, that there seem to be only two chances for its recovery as a commercial speculation: either that the government purchase it and throw it open to the public; or that it be brought into use as a railway viaduct over the Thames. It is, however, as a matter of engineering and not of commercial speculation that the bridge is spoken of here. Southwark Bridge crosses the Thames from Bankside, near the Three Cranes' Wharf, to the Middlesex bank near Queenhithe. Like Putney, Battersea, Vauxhall, Westminster, Waterloo, and Blackfriars bridges, it had to contend against the opposition offered by the Corporation of London—a circumstance which, in future ages, when local jealousies become forgotten, will strike an observer as being no little remarkable in a commercial country like England.

The following account of this fine bridge was given in 'London,' No. 61:—"The bridge was begun on the 23rd of September, 1814, and the first stone of the south pier laid by Lord Keith on the 23rd of May, 1815, who, with the other gentlemen of the committee of management, partook of a cold collation on a temporary bridge erected on the works. The whole was finished in less than five years, and was opened, without any particular ceremony, at midnight (the bridge being brilliantly lighted with gas), in April, 1819. As an iron bridge this is confessedly without a rival. The arches are, for instance, the largest in existence, the centre one having a span of two hundred and forty feet, and each of the two side ones measuring two hundred and ten feet. The arch of the famous bridge at Sunderland has a span very nearly equal to this centre arch, but still it is less. As we now pass beneath this gigantic semicircle, and gaze upward upon the great iron-ribbed framework which supports it, one feels half unconsciously inclined to fancy Cyclopean hands must have been here at work. But the engineer, in the sublimity of his views, smiles at our wonder, and tells us that Telford had previously proposed to erect a bridge at this spot with *one* arch only: "the force of *wonder* can no further go;" we do not know, in these days, what we may venture to disbelieve. With the exception of the piers and the abutments, the whole of Southwark Bridge is of cast-iron. The preparing the foundations was a work of unusual magnitude and expense, on account of the extraordinary dimensions of the arches; of still greater difficulty and importance was the business of casting the superstructure, which took place at the iron-works of Messrs. Walker and Co., Rotherham, Yorkshire. Many of the solid pieces of casting weighed ten tons. There are eight great ribs, from six to eight feet deep, riveted to diagonal braces, in each arch; and the height of the centre arch above low water is fifty-five feet. The entire weight of iron is about 5780 tons. In building the bridge a mistake was committed that might have been attended with serious consequences, if timely discovery had not been made. To prevent the natural expansion of the metal with heat, some of the most important joinings of different parts of the work were tightly wedged with iron wedges. But as, in fact, nothing could prevent expansion under the operation of heat, it was found that a very unequal strain was produced, tending to the fracture of the entire bridge. The masons were accordingly employed night and day till the wedges were removed. Having mentioned this oversight, it is but proper to state that the accuracy of the work generally was most surprising. The centre arch sunk at the vertex, on removing the timber framework, just one inch seven-eighths, and that was all."

Suspension Wire-Bridges.

A suspension-bridge differs from those which have hitherto engaged attention in this circumstance—that the roadway, instead of pressing or resting on a firmly built arch beneath, is hung or suspended from mechanism above, so as to oscillate to and fro, quite independent of any support from the abutments at the two ends of the bridge.

The rope bridges, already described, are in effect suspension-bridges, since the material employed is yielding and flexible in its character; but they are wanting in many of the features presented when iron is employed for the suspensory mechanism. Split bamboos, and the "coire" or fibre of the cocoa-nut, are occasionally used for such a purpose in the East: thus, one has been made in Calcutta, of which the span is a hundred and twenty-five feet, and the width six and a half; the platform being made of bamboos laid in coire-ropes, which are in turn suspended from others. In various parts of Europe, such as near Stoffingen in Switzerland, and near Innspruck in the Tyrol, are ancient bridges suspended from chains made of long pieces of wood, put together with iron pins. There are two or three of a similar kind in Franconia and other parts of Germany.

The use of *wire* for such purposes has been successfully adopted in several instances. There was a bridge suspended by wires, built over the Gala Water in Scotland, in 1816; its span was a hundred and eleven feet, and yet it is said to have cost no more than 40*l.*! This was in 1816; and in the following year another was built across the Tweed, at an expense of 100*l.*; the platform of this bridge was four feet wide, and was sustained by wires radiating from the tops of two cast-iron columns at the ends of the bridge; the columns were cast hollow, and within each of them was placed a vertical bar of wrought-iron, two inches and a half square, to which the wires were attached. Another such bridge, built on a larger scale, was constructed across the Rhône at Tournon, in 1824-5, having two openings of rather more than two hundred and seventy-eight feet each.

But the finest wire-bridge yet erected is that at Fribourg in Switzerland. There is a small but rapid river, the "Sarine," which descends from the Fribourg Alps; and after winding along a very beautiful and romantic valley, flows past the city of Fribourg, and falls into the river Aar a little above Aarberg. It turns at an angle round the base of the rock on which Fribourg is built; and the ground here descends towards the river to the south of it, with a very steep slope, and is quite perpendicular on the north-east. The principal part of the town, containing the Cathedral and other chief buildings, is built along the precipitous side, which rises from two to three hundred feet above the bed of the river. The width of the valley on this side, at the height of two hundred feet, is not above three hundred yards. Fribourg had always been an interesting object to travellers; but its situation, and the great difficulty of the approach, frequently deterred them from visiting it; and the only way of travelling from Fribourg to Berne was especially incommodious and dangerous. Under these circumstances, the inhabitants subscribed funds enough to build a bridge, and confided the execution of it to a French engineer, M. Chaley.

The very elegant wire suspension-bridge, which was the result of M. Chaley's labours (Fig. 1290), is at the same time one of the most skilful and the most beautiful bridges ever built. It consists of a platform suspended from wires, which wires are held up by piers or towers at the two ends. On approaching the bridge from either end, we come to a pier of solid masonry (Fig. 1296), in which an arched opening gives access to the bridge. The pier rises sixty feet above the roadway, and seventy-five above the foundation; the width is forty-two feet, and the depth eighteen. The foundation is on a hard and solid rock, at a distance of thirty feet within the edge of the precipice. The great suspension chains by which the platform of the bridge is supported, after passing over friction-rollers on the top of the pier (Fig. 1294), are similarly buried in the same solid rock, far beneath the surface of the ground. These friction-rollers, as placed on the top of the pier, are of cast-iron, and each one supported on a massy block of Jura limestone. The section of the bridge is shown in Fig. 1287. A small semicircular terrace intervenes between each of the piers and the bridge, by which room is afforded for the toll-houses; and from these a magnificent view is obtained of the surrounding scenery: thus, in Fig. 1295, the dotted portion of the engraving represents the open terrace, between the pier on the one hand and the commencement of the bridge on the other.

Thus far as respects one end of the bridge only, and the other is similar to it; but the mode of suspending the platform of the bridge is the point which attracts the most attention. This support is afforded by four wire cables, which are suspended in pairs from pier to pier, forming a curve of which the "chord," or horizontal diameter, is eight hundred and seventy feet, and the vertical bend in the middle fifty-five, where they come down within a foot of the roadway. This roadway, twenty-two feet in width, is formed of fir-planks resting on rafters, which are again supported by beams placed on each side of the bridge, where they rest on strong iron stirrups. A raised path for foot-passengers, three feet in width, runs on each side. There is a hook at the upper part of the stirrup which passes into the loop of a cord or wire, at the upper end of which is fixed a double hook embracing two of the cables (Fig. 1302). The beams are in this manner suspended at both ends from the cables; and as long as this suspension remains uninjured, the supported roadway maintains its proper position. The beams are a hundred and sixty-three in number, and are placed at a distance of between four and five feet apart. The rafters, on which the planks of the road are strongly fixed, lie across the beams, to which they are firmly bolted. Great additional stiffness is given to the whole by an oaken railing surmounted by a strong top-rail.

The wires by which and from which all this heavy mass is suspended, are prepared in a very remarkable manner. We must distinguish the *cables* from which the platform is suspended, and the *cords* by which the connexion between the two is maintained—the former following a graceful curve from pier to pier, and the latter being vertical. The cords are each composed of thirty wires, about one-twelfth of an inch in diameter; and as each of these was made with a degree of strength sufficient to support, without breaking, a weight of twelve hundred pounds, and as there are a hundred and sixty-three pairs of them, they are able collectively to sustain a weight of five thousand tons. The cables are composed of similar wires, formed into fifteen bundles of eighty wires each: they are not twisted like the strands of a hempen cable, but each wire goes straight from end to end; and the whole fifteen bundles are firmly tied into a cylindrical form by means of annealed wire wound round the whole, at intervals of two or three feet. Two such cables are placed close together on each side, and pass over the friction-rollers on the piers. Each of the cables thus consists of one thousand and fifty-six wires, and forms a cylindrical bundle between five and six inches in diameter.

Near the piers the cables lose their cylindrical form, and are flattened out into a kind of ribbon, to enable

them to pass more readily over the rollers at the top of the piers: they extend, indeed, to a width of nearly thirty inches, but afterwards resume the cylindrical form when they have passed over the rollers. The means adopted for receiving them on either bank are very efficient. The cables descend diagonally to about the level of the ground; they then pass down slanting tunnels to a certain depth, and finally down vertical pits or chimneys. Each of these pits (Fig. 1298) is forty-five feet deep, and has a number of bevelled cavities cut in its sides. The cavities are filled with well-wrought masonry, so as to stop any upward passage; and through the centre of this masonry is made a cylindrical bore or channel, large enough to admit a cable. At the bottom is a very large block, with a hole bored through the centre; the cable is passed through it, and fixed round a very strong piece of iron, which constitutes a kind of anchor, and bears the whole strain. The cable here spoken of is not the main cable, five or six inches in diameter; but each one of the four main cables is at each end joined to two smaller ones, so that there are sixteen of these smaller cables, all secured in this way. These smaller cables are each composed of five hundred and twenty-eight wires, and are twenty-seven yards long, with a diameter of rather less than four inches.

All the separate bundles, to form each cable, were made up separately, and all were adjusted to the end cables in the wells, and to the friction-rollers over the piers, before being made to form the general curve of the bridge. They were raised from pier to pier without much trouble, each of the fifteen bundles being raised separately, and then the whole firmly connected. The descending cords were then hooked on, the stirrups affixed, and the beams put through them. In this manner the road was carried forward rapidly, and the bridge completed. The lengths of the cords are so adjusted that the bridge rises a few feet in the middle, which tends to lessen vibration; the cords are consequently longer and larger as we approach the piers at either end, where they are as long as the piers are high. Every wire, before being used, was stretched and tested separately; every wire was afterwards painted and varnished separately; and the whole of the bundles were also painted collectively.

Of the circumstances which led to the adoption of wire as a material for this bridge, the following account s given in the 'Penny Magazine:'—"Many ingeniously-constructed wooden bridges are to be found in all parts of Switzerland; and that over the Rhine at Schaffhausen, which was destroyed in the last war, has been celebrated for the boldness of the span, which was three hundred and sixty feet. The idea of a bridge over the valley of the Sarine at Fribourg was more than once entertained, and proposals and plans were made; but the required height of the piers, and the danger from gusts of wind to a bridge so exposed, and which, if roofed in (as is the case with most of the Swiss bridges, and essential to their duration), would present too great a surface to the storm, appeared insurmountable obstacles. When suspension-bridges became more generally known, the idea of a bridge revived; but all calculations of the expense of the common iron chains, or rods of suspension, where iron is so dear, deterred any one from undertaking it. The same difficulty had led to the substitution of wire, of which a small foot-bridge was constructed in 1823 over the Fossi at Geneva; and in 1825 M. Seguin constructed a larger bridge of wire over the Rhone. On the plan of these, M. Chaley, a French engineer (who, in partnership with M. Seguin, jun., had built a wire bridge over the Rhone at Beaucaire in 1829), proposed to erect one at Fribourg; and, after some negotiation, he contracted for it on the following conditions:—1. The ground for the works to be provided, and the approaches made for him; 2. Three hundred thousand francs (12,000*l.*) to be paid him as the works proceeded; 3. The receipt of all the tolls for forty years from the opening of the bridge. In consideration of these benefits, M. Chaley engaged to finish the bridge according to the plans agreed upon, at his own cost and risk, having the option of constructing it with two spans or only one; and to keep it in repair for forty years, at his own cost. The option of a bridge with two spans was inserted to satisfy some of the parties who had a prejudice against so great a span as impracticable; but M. Chaley never for a moment entertained any other idea than that of a single bridge. The pier, which must have been built in the middle, must have been upwards of two hundred feet high, and have had a very deep foundation. The expense of it would have been enormous, and the effect far inferior.

"The whole bridge, as it now stands, cost M. Chaley only six hundred thousand francs, an extremely small sum considering the expense of the materials. The wire was drawn at Brienne from iron forged in the Canton of Berne. The strength of the cables of suspension is calculated to be sufficient to support on the bridge, without breaking, a load of nearly five hundred tons. The greatest load which can be upon it at any one time, in carriages, horses, and men, does not exceed a hundred and sixty tons. It was tried in the severest way before it was opened to the public; for a train of artillery of fifteen pieces of large cannon, with fifty horses, and three hundred men, passed over it on the 15th of October, 1834. Soldiers marched and countermarched over the bridge, and men were crowded as close as they could stand on different portions of the bridge, which made it sink several feet at these points. On the 19th it was publicly opened, and above two thousand persons were on the bridge at the same time."

Suspension Chain-Bridges.

By far the larger number of iron suspension-bridges have been made of *chain* instead of *wire*; the latter having formed the exception rather than the rule. In all chain bridges the roadway is suspended from a connected series of iron links, which, by the easy play of their pivots or joints, assume the same gracefully curved form as a wire would naturally do; the flexibility of the wire being, in the case of the chain, imitated by the action of the joints between the several links.

The appearance of a suspension-bridge made of chain does not differ much from one made of wire. The magnificent "Menai" Suspension Bridge (Figs. 1286, 1293), the Isle of Bourbon Bridge (Figs. 1291, 1292), and others which will shortly engage our notice, show that the same general principle is adopted, though varied in details. The Bourbon bridge is, perhaps, the most distinctive, in having a central pier in the middle of the river.

Captain Turner, when he visited Bootan about sixty years ago, met with a very ancient bridge which was in effect a chain bridge, although not on the suspension principle as now practised. It crossed the river Tchin-Tchieu near the castle or fort of Chuka, and was called Chuka-Chagum. The river runs between precipitous rugged banks, of unequal height and declivity, in the steepest of which is a solid pyramidal pier of masonry, having an opening through the top for the roadway: in this opening is fixed a strong double frame like a doorway. On the other side of the river, at a little distance from the bank, there is, on the corresponding pier, a square building, containing a chamber which serves as a sort of ante-room to the bridge; and from the foot of this building a covered timber gallery projects to the edge of the river, a distance of about thirty-five feet. There are five main chains of iron, to form the floor of the bridge, secured to the front wall of the building; and, after passing over the lower beams of the gallery, they are attached to the bottom of the frame in the opposite pier. Another chain on each side of the bridge is fixed, nine feet above the former, to the top beam of this frame; and these two, being carried through the wall of the chamber, pass down to the ground, where they are secured. From these two upper chains hang vertical suspending rods to the outer ones of the floor-chains, which they thus assist to support, while they form a parapet to the bridge. The roadway is covered with strips of bamboo. Another bridge was found by the same traveller in the same district, more nearly resembling those of European construction. Two chains, four feet apart, were stretched across, carried over a pile of stones raised on each bank, and after descending through a sloping passage cut in the rock, they were fastened to a large stone at the bottom, which was kept down in its place by a mass of rock and stones heaped on it. A single plank for a footway was suspended four feet below the chains, by means of roots and creeping stems attached to them on either side. The length of the bridge was seventy feet.

One of the earliest chain suspension-bridges known in Europe was built over the river Tees near Middleton, in the year 1741: it was intended for foot passengers only, and was elevated about sixty feet above the river. The first bridge of this kind in America dates back to about the year 1796, when Mr. Finley constructed one about seventy feet in length. Soon after this, the same engineer took out a patent for certain improvements in the mode of construction, and built several suspension-bridges; one of which, over the river Schuylkill, was more than three hundred feet in length.

The most notable of all suspension-bridges, in relation to its magnitude and strength, and perhaps also in respect to the difficulties attending its execution, is the beautiful Menai Bridge constructed by Telford over the narrow strait which separates Anglesey from the mainland of Wales. Before the execution of this bridge, the communication between London and Dublin by way of Holyhead was greatly impeded, because there were no means of passing from Caernarvonshire into Anglesey (where Holyhead is situated) without ferrying across the Menai Straits, by one or other of six ferries, the chief of which was at Bangor. To form a land-connection between the two shores of these straits became therefore a desirable object, and at different times suggestions were made bearing on the subject. It was about the year 1810 that Telford was engaged by a Government Commission to make a survey of the road from Shrewsbury through Chester to Holyhead, and to prepare plans for a bridge over the straits. He prepared two plans: one for a bridge of three cast-iron arches, each with a span of two hundred and sixty feet, and two alternating stone arches of a hundred feet span each; the other was for a single cast-iron arch of five hundred feet span, at a narrower part of the river. The subject of a bridge at Menai, although deemed important, was not taken up so earnestly by Parliament as to lead to anything definite for many years; but at length, in 1818, a sum of 20,000*l.* was voted to commence operations; and a plan sent in by Telford was finally approved.

According to this plan, the site fixed upon was near a place called Ynys-y-Moch, where the opposite shores were very bold and rocky, and where the roadway of the bridge would be a hundred feet above high-water mark. In July, 1818, the engineers commenced building workshops, levelling for the foundations, and making other preparations; but various obstacles prevented them from making much progress until the autumn of 1819; after which time the works proceeded steadily, but not rapidly. The first stone was laid in August, 1819. The three land-arches on the Caernarvonshire side were keyed in the spring of 1822; and the three at the opposite side in the autumn of the same year. In March, 1823, the iron-work for the attachment of the main-chains to the rock was begun to be fixed; in May, 1824, the iron-work of the pyramids or towers was adjusted; and in the summer months of 1825 all the chains were fixed. At length, on the 30th of January, 1826, the first mail-coach passed over the bridge. Shortly after this opening, however, an exceedingly violent gale did considerable damage to the iron-work; and repeated gales during the spring tended greatly to retard the necessary repairs. The repairs were completed with some difficulty, and the bridge has ever since been safe and commodious, likely to afford valuable service until railways shall render it comparatively useless—a period that does not seem very remote, if the scheme for carrying the Chester and Holyhead Railway over the Menai Straits, at a point some distance from Telford's Bridge, should be acted on, as sanctioned by Parliament and the Government.

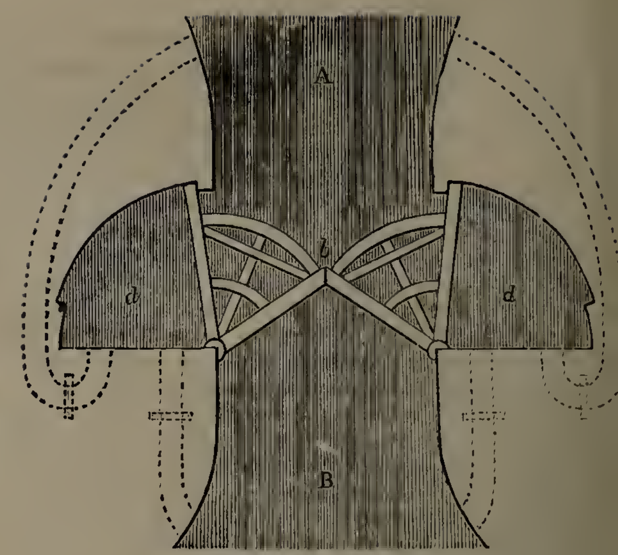
The Menai Bridge (Figs. 1286, 1293) is five hundred feet long from pier to pier; the roadway is elevated about a hundred feet above high-water level, and is twenty-eight feet wide, being divided into two carriage ways of twelve feet each, with a footway of four feet between them. The roadway is supported by sixteen main chains, the links of which consist of iron bars ten feet long: these links are jointed together end to end by the intervention of smaller bars. These chains contain the enormous weight of four hundred tons of iron; and the weight of the roadway and mechanism suspended from the chains is about two hundred and fifty tons. The chains are secured on either shore much in the same way as the wire chains of the Fribourg Bridge, in tunnels or pits excavated in the rock.

These ponderous chains were raised in the following manner:—The parts within the tunnels in the rocks were put together link by link, from the holding-bolts at the bottom. A scaffolding was erected from the mouths of the tunnels, supporting a platform which reached to the tops of the piers; and the chains were put together on this platform till they reached over the top of the pier. A cradle, capable of holding two workmen, was suspended by tackle from the top of the pier, on the Caernarvon side, so that the men could raise or lower themselves at pleasure. The links were brought to the face of the pier next the sea, from whence each link was raised to the proper height where wanted; it was then put on to the former link by the men in the cradle. Proceeding in this way, the chain was carried on downwards to the level of the water. The remaining portion of the chain that was to unite the two ends, was laid on a raft four hundred feet long; one end of this piece being joined to that which hung down from the pier, the raft was floated across, and the other end of the chain was made fast to a powerful tackle, which was raised by two capstans worked by a hundred and fifty men. The loose end of the chain was thus raised high enough to be fastened on the Anglesey side. All the other fifteen chains were raised in a similar way.

Of this beautiful bridge it has been said that it "occasioned Mr. Telford more intense thought than any other of his works. To a friend, a few months before his death, he stated that his anxiety for a short time previous to the opening was so extreme, that he had but little sound sleep; and that a much longer continuance of that condition of mind must have undermined his health. Not that he had any reason to doubt the strength and stability of any part of the structure; for he had employed all the precautions that he could imagine useful, as suggested by his own experience and consideration, or by the zeal and talents of his able assistants; yet the bare possibility that some weak point might have escaped his and their vigilance in a work so new, kept the whole structure constantly passing in review before his mind's eye, to examine if he could discover a point that did not contribute its share to the perfection of the whole."

The suspension bridges built since the Menai are very numerous. Figs. 1291, 1292, represent a bridge which Sir M. I. Brunel built in the Isle of Bourbon, about twenty years ago: it has a lofty pier in the

1307.—Suspension-bridge over the River Aire at Hunslet, near Leeds.



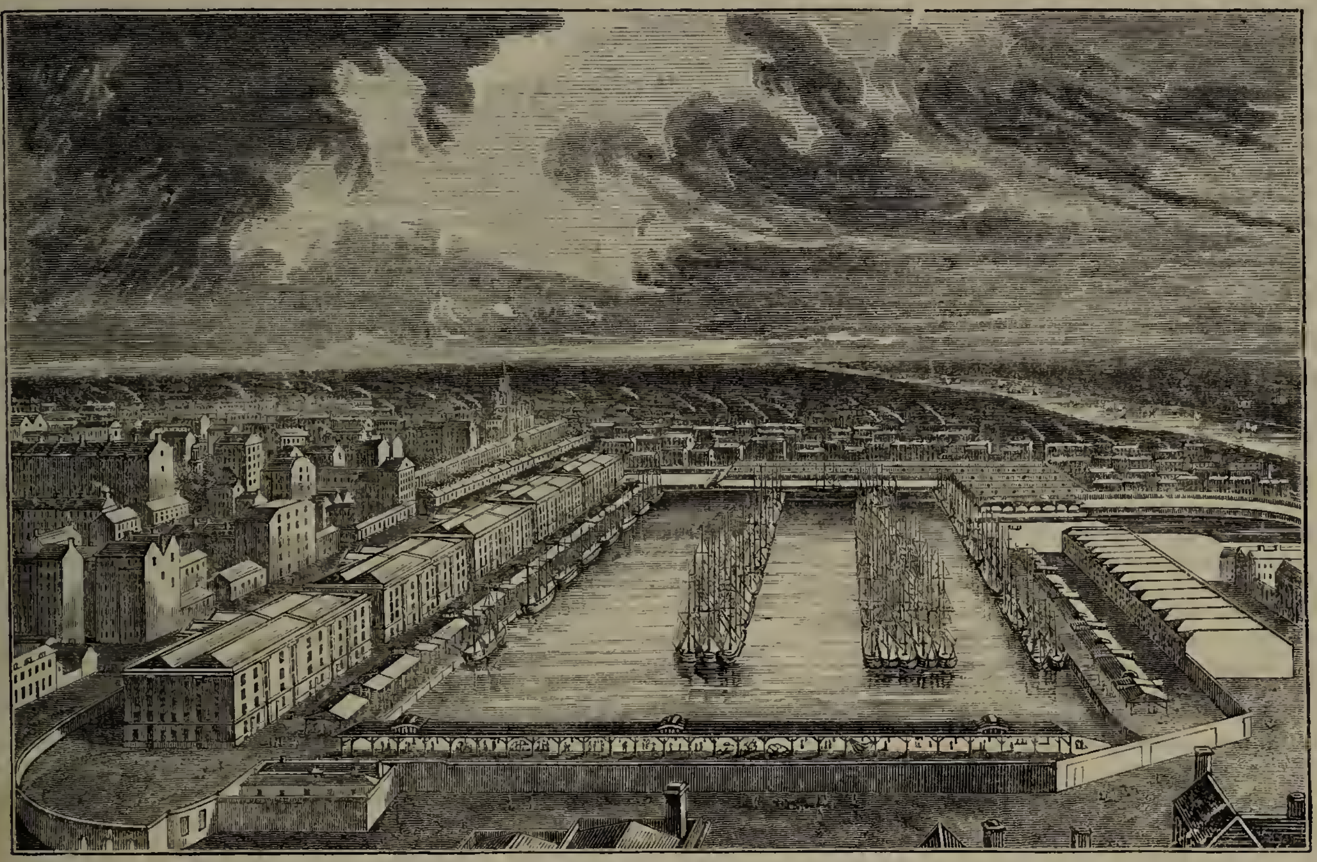
1308.—Sluice or Water-gates.

1309.—Outer extremity of the Suspension Chain-Pier, Brighton.

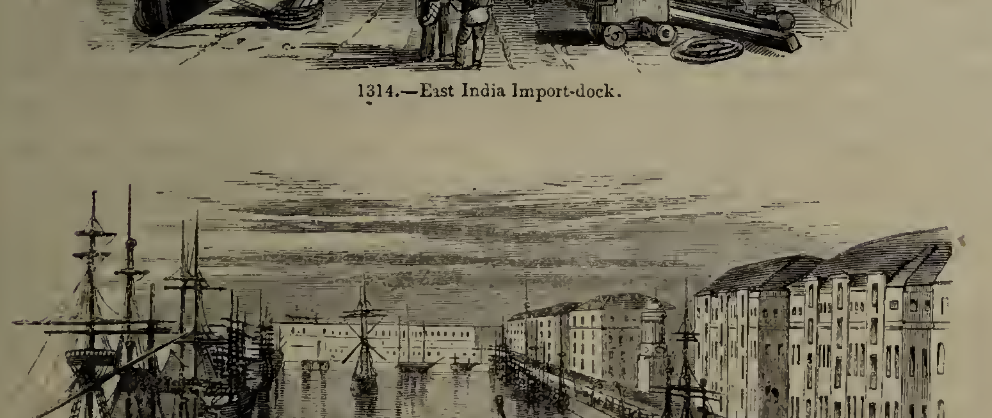
1310.—Plan showing the general arrangement of the Docks at Liverpool.


1311.—Entrance to the Canal Tunnel at Worsley.


1312.—Canal Aqueduct over the Irwell.


1313.—London Docks.


1314.—East India Import-dock.


1315.—West India Dock.


1316.—View through the Thames Tunnel.

centre, instead of two piers at the ends; and in so far it differs from the generality of suspension bridges. Scotland has been beautified with several specimens of such bridges within the last few years. In Fig. 1300, for instance, is a sketch of the suspension bridge built over the River Dee at Aberdeen. Near Montrose, over the South Esk, has been built a similar bridge (Fig. 1301). In Fig. 1304 we have a plan and elevation of a very simple suspension bridge made of slight iron rods, built by Messrs. Smith at Dryburgh, in 1817. This bridge was destroyed shortly after its erection, and was replaced by another, of which an elevation is given in Fig. 1305. The Findhorn suspension-bridge (Fig. 1306), near Elgin, is remarkable for the castellated appearance of the piers at the ends.

The very remarkable suspension bridge over the Avon at Clifton, near Bristol, has suffered from an ailment which occasionally afflicts engineering projects —want of funds. Near Bristol, the Avon flows through a deep cleft at St. Vincent's Rocks; and a plan was formed several years ago for connecting the two sides of these rocks by a bridge, at such a height from the water as should allow merchantmen of the largest class to sail beneath it. Mr. Brunel undertook the bold project, and drew out the plan. The general elevation and entrance of the bridge, as designed by him, are given in Figs. 1297, 1299. According to the plan proposed, the length of the bridge from pier to pier was to be about seven hundred feet; the height of the roadway above the water, two hundred and forty feet; height to the top of the pier, one hundred feet more; width of the bridge, thirty-two feet. But the plan has not had the good fortune to be carried out: the two piers are erected, and have remained as they now are for many years; but commercial difficulties have prevented the further prosecution of the enterprise.

The Brighton Chain-pier (Fig. 1309) is a favourable example of the adoption of the suspension principle for such an object. This pier consists of a platform about a thousand feet long by thirteen wide, suspended from eight chains which pass over four towers: the chains being at one end fixed in the cliff, and at the other end fixed in masonry sunk in the sea. The towers are made of cast-iron, and each one rests upon twenty piles, driven with more than the usual force into a bed of chalk. In October, 1833, this pier was injured during a violent gale, but afterwards restored.

The fine suspension bridges over the Thames at Hammersmith and at Hungerford are well-known specimens of this kind of structure; and the small bridges in the Regent's Park are examples of a mode of arrangement brought into use within the last few years, in which there is a singularly small consumption of iron: a great portion of the heavy weight of the chain being dispensed with. Another mode of obviating the weight of the chain has been adopted by Mr. Leather, at Leeds, and other parts of the north. Fig. 1307 represents one of these bridges. The roadway, instead of being suspended by vertical or oblique rods from chains, is supported by an arch of cast-iron, resting on abutments at the two ends. The arch is formed of several parallel ribs of iron, which are made firm and rigid, and from the concave under surface of the arch so formed vertical rods descend to support the roadway.

CANALS AND TUNNELS.

The department of engineering which relates to bridges involves *construction* rather than *excavation:* the formation of tunnels requires more excavation than construction; while canals, in the same manner as railroads, call for repeated examples of both.

Canals, as Works of Engineering.

The consideration of canals as a means of transit occupied a little notice in Chapter V.; but a few remarks may here be made concerning them as matters of engineering.

The efficient working of a canal always depends on the position which it holds relative to some body of water which may serve as a reservoir. There must be a perfect level between one lock and another, in order that a heavily laden barge may proceed as easily up the canal as down; and there must also be a supply of water to replace that which flows into and out of the locks. In forming the general level, the engineer allows embankments and excavations to alternate; generally in such relative proportions that the quantity of rock or earth dug out of all the excavations shall be about equal to that required for all the embankments. The sides of a canal are not often made vertical: they are in most cases oblique or sloping, as a means of preventing the upper edge of the bank from being undermined by the action of the water. The canal is often made larger than it is intended to be when finished, in order that a thick layer of stiff clay may be laid on the sides and bottom, to prevent the infiltration of water.

The obtaining of a supply of water for the canal often calls forth a good deal of consideration on the part of the engineers. In some cases, such as that of the Great Ship Canal in Holland, both ends come to the open sea, and nothing more is wanted than to establish a communication of running water from sea to sea. In the majority of cases, however, where a canal is above the level of the sea, either rivers or land-springs are made to furnish a supply. Sometimes the canal at its upper or higher end communicates with a river, some of whose water flows into it. In other cases, where the canal has to cross an irregular district of country, it is found advantageous to form a reservoir in some valley or recess between hills—sufficiently low to collect the flood-waters from a large surface of country, but at the same time sufficiently high to enable all the water it contains to flow to the summit of the canal. A short line of cutting, or a sort of trough, is in such cases made from the reservoir to the canal, to form a "feeder;" or sometimes a natural brook course, leading from the reservoir to the canal, is made to act as a feeder. At any rate, be the arrangement what it may—whether the water is obtained from the sea, from a river, from a land-spring, or from rain water collected in reservoirs—one of the first considerations on the part of the engineer is to see that this supply is of such a kind as to be ample enough to renew the quantity lost by waste and evaporation.

The modes of crossing valleys by embankments and viaducts (or rather aqueducts), and of piercing hilly ridges by cuttings and tunnels, are of pretty general character in relation both to canals and to railways. In Fig. 1312 we have the aqueduct by which a canal is carried over the river Irwell; and here may sometimes be seen the curious spectacle of one boat passing over the mast of another.

The *locks* by which a canal is made to accommodate itself to the undulating surface of a country, are a very ingenious contrivance. The current of a running stream would never do for a canal, since it is essential that the heavy traffic of goods should be carried with equal facility in both directions. Hence canal engineers had to solve the question, how to ascend and descend steep inclines, and yet retain the water practically level. The Chinese use very curious but clumsy means to effect an ascent, by dragging the boats up a wooden incline which connects one level of the canal with another; and various other contrivances were adopted or suggested in England previous to the use of the lock; but this has now superseded all the others. Where a canal passes along a gradually rising country, it is divided into different portions or lengths called "pounds," each pound being bounded at the end by two locks; the upper one of which separates it from a pound on a higher level, and the lower one from another pound on a lower level. If the lock is a "double" one (which is the most complete form) it consists of two oblong tanks or chambers, both provided at both ends with wooden gates. If the upper gates of both chambers are open, and the lower ones closed, the water in the chambers is on the same level as in the upper "pound:" if the lower one be open, and the upper ones closed, the level of the water is the same as in the lower pound; if one chamber is closed at the upper end, and the other at the lower end, the water will stand at different levels in the two chambers. There are sluices or flood-gates to let water flow from the upper "pound" into the lock, from either chamber of the lock into the other, and from the lock into the lower "pound." By the management of these several pairs of gates, then, and of the several sluices, the level of the water in either chamber can be made equal to that in the upper pound, or in the lower pound, at pleasure; and by such means a barge is floated either upwards or downwards, according to the direction in which it is passing. The "lift" of a lock, or the difference of level between the two "pounds" which it separates, varies from one to eighteen feet, but is generally about six or eight.

Sometimes, where the supply of water is rather scanty than otherwise, means are adopted for saving the water otherwise wasted by "lockage," by having side ponds into which some of the water from the lock is made to flow. Most canal companies have a clause in their act of parliament, empowering them to search for, and to divert to their use, all springs of water within certain limits on either side of their line, as feeders for the canal: the distance so limited varying usually from one to two thousand yards on either side of their line; but in some scantily-watered districts the supply thus obtained is so small, that the companies are glad to avail themselves of every means to economise it.

Tunnels for Canals and Railways.

The tunnels by which our principal canals and railways pierce through hills are among the most remarkable of engineering works. The excavators and bricklayers have to grope for so many months in the dark, and the engineer is subjected to such trying difficulties in relation to the quality of the ground through which the works are conducted, that tunnelling is always regarded among the most formidable works of a canal or railway.

A tunnel would not be made if it were more convenient to make an open cutting through a hill; but the height of a hill, or the existence of valuable property on its surface, often prevents the use of a cutting, and then a tunnel is the only alternative. Thus, in carrying the Regent's Canal from the west side to the east side of Islington, it would have been almost impossible to effect the passage by an open cutting, and thereupon a tunnel was made, three-quarters of a mile in length. The Edinburgh and Glasgow Railway, when it arrives at a point directly north of the city of Glasgow, strikes off southward to reach a central terminus; but as a great destruction of buildings, and heavy engineering works, would have been required to make it an open cutting, the passage was made by tunnel. The same thing has occurred at Liverpool, where the railway arrives from Manchester to the outskirts of the town at Edge Hill: no means offered of reaching the docks and the heart of the town except by tunnels, two of which were constructed about a mile and a quarter in length each.

In relation to canal-tunnels it is remarked in the 'Penny Cyclopædia' that "They are generally of small transverse dimensions, being calculated for the passage of single boats, and very often without towing-paths, in which case the boats are either hauled through by a rope or chain worked by a steam-engine, or propelled by men lying on their backs on the deck, or on projecting boards provided for the purpose, and thrusting against the sides or roof of the tunnel with their feet. This dangerous practice has occasioned much loss of life, and is also objectionable on account of its tediousness, as boats are often detained for a long time at one end of the tunnel while a boat is coming from the opposite end. In the evidence before the House of Lords on the Great Western Railway Bill, in 1835, it was stated that great delays were experienced at the Islington tunnel when any accidental derangement prevented the steam-engine and chain from working; because, although boats were occasionally "legged" through in as little as seventeen minutes, the ordinary time for working a light barge through the tunnel, by two men, was half an hour, and for a loaded barge three-quarters of an hour, or frequently an hour. In such cases boats arriving in the opposite direction had to wait at the mouth of the tunnel, until frequently as many as half-a-dozen were collected, which, when their turn arrived, passed through in a train. At some of the longer tunnels this inconvenience was even greater. At the Harecastle Tunnel, on the Trent and Mersey, or Grand Trunk Canal, two hours were formerly required to effect a passage of little more than a mile and a half. 'This place is so frequented,' observes the Baron Dupin in his 'Commercial Power of Great Britain,' 'that at the moment when the passage begins a file of boats a mile long is often seen.' To prevent confusion those going towards Liverpool were allowed to pass in the morning only, and those in the contrary direction in the evening. This tunnel, which was formed by Brindley, and was one of the earliest works of the kind executed in this country, was commenced about the year 1766. It is two thousand eight hundred and eighty yards long, twelve feet wide, and nine feet high, and is in some parts as much as seventy yards beneath the surface." The inconveniences of this narrow tunnel were borne with for more than half a century; but at length, in 1822, Telford was employed either to widen the tunnel, or to construct a new one by the side of it: the latter course was adopted. The new tunnel is a little longer than the old one, and considerably larger both in height and width. The water extends across the whole width of the tunnel, but there is an iron towing-path for the men and horses, suspended over the water.

The Worsley Tunnel, forming part of the first great work which Brindley executed for the Duke of Bridgewater, is in fact a series of tunnels, perforating the ground throughout a large area of country, and extending collectively to a length of several miles. One of the entrances to this tunnel is sketched in Fig. 1311, as copied from a print published in the last century. The object of this network of tunnelling was to bring several coal-mines into communication with one general outlet, whereby their mineral wealth might be conveyed to Manchester.

In the construction of a long tunnel engineering works of great magnitude and difficulty have to be attended to. The nature of the ground has first to be tested, to see whether there are any land-springs which will be liable to inundate the works. So trying are the difficulties which often arise to an engineer, when the soil through which a tunnel is excavated turns out to be more loose and watery than was expected, that in the case of the Kilsby Tunnel on the London and Birmingham Railway, the outlay exceeded the estimate by nearly a quarter of a million sterling! Shafts have to be sunk, to enable the miners to work at several points at once; since, if they only began at the two ends, and worked onwards until they met in the middle, the operation would proceed very slowly; but by sinking several shafts, or vertical pits, down to the level of the tunnel, the men can work right and left from the bottom of each shaft, and the earth and rock dug out can be hauled up the shaft. Sometimes the soil is so loose and soft that a steam-engine has to be constantly employed to pump up the water which flows from it; while in other instances

the rock is so hard as to require blasting with gunpowder. When the soil is soft a brick arching requires to be carried throughout the tunnel; but when it consists of hard rock the sides and roof often support each other without any arching.

There is given, in the work lately quoted from, a table of the lengths of all the railway tunnels in England exceeding about four hundred yards: we will extract from it all those of a mile and upwards, which will give some idea of the great extent to which this difficult department of engineering has been carried. That table was published in 1843, and included those tunnels which were then in course of construction, as well as those actually finished; but there have since been others determined on, arising out of Acts of Parliament obtained in the last two sessions:—

RAILWAY TUNNELS A MILE AND UPWARDS IN LENGTH.

	Yards.
Summit Tunnel, on the Sheffield and Manchester Railway	5192
Box Tunnel, Great Western Railway	3227
Littleborough Tunnel, Manchester and Leeds Railway	2869
Sapperton Tunnel, Cheltenham and Great Western Railway	2800
Kilsby Tunnel, London and Birmingham Railway	2423
Wapping Tunnel, Liverpool and Manchester Railway	2250
Lime-Street Tunnel, Liverpool and Manchester Railway	2230
Clayton Tunnel, London and Brighton Railway	2200
Abbot's Cliff Tunnel, Dover Railway	2000
Watford Tunnel, London and Birmingham Railway	1793
Merstham Tunnel, London and Brighton Railway	1780
Leicester Tunnel, Leicester and Swannington Railway	1760
Clay Cross Tunnel, North Midland Railway	1760

It thus appears that there are thirteen railway tunnels in England a mile and upwards in length, and this number will be increased in the course of a year or two. It seems probable that the Sheffield and Manchester Tunnel, very little short of three miles in length, will ever remain the longest railway tunnel in England; for the power of the locomotive to surmount an incline is found to be greater than it was supposed to be at the time when most of the above tunnels were planned; and the greater this power the less need will there be of making long tunnels.

The English canals, however, can exhibit a system of longer tunnels than the railways, taken collectively. The following table will show how numerous are the canal tunnels exceeding two thousand yards in length:—

CANAL TUNNELS A MILE AND UPWARDS IN LENGTH.

	Yards.
Marsden Tunnel, Huddersfield Canal	5280
Sapperton Tunnel, Thames and Severn Canal	4300
Pensax Tunnel, Leominster and Kington Canal	3850
Laplat Tunnel, Dudley Canal	3776
Blisworth Tunnel, Grand Junction Canal	3080
Ripley Tunnel, Cromford Canal	3000
Dudley Tunnel, Dudley Canal	2929
Harecastle Tunnel, Trent and Mersey Canal	2888
Norwood Tunnel, Chesterfield Canal	2850
West Heath Tunnel, Worcester and Birmingham Canal	2700
Morwelham Tunnel, Tavistock Canal	2300
Oxenhall Tunnel, Hereford and Gloucester Canal	2192
Braunston Tunnel, Grand Junction Canal	2045

There are several others whose lengths are intermediate between a mile (one thousand seven hundred and sixty yards) and two thousand yards, but these need not be given in detail. The Worsley Tunnel is also omitted, because, in fact, it consists of a whole series of tunnels not far short of twenty miles, collectively, in length.

The Thames Tunnel.

The most remarkable tunnel in England is that which Sir M. I. Brunel has constructed under the Thames at Rotherhithe. As in the instances of Waterloo and Southwark bridges, the undertaking has been a miserable failure to the proprietors, and this is a kind of disappointment to which engineers are very subject; for though they are not responsible for the commercial success of the works which they execute, yet there can be no doubt that it would be gratifying to an engineer to know that while the result of his labours brought honour and emolument to himself, it also brought an adequate return for the capital of those who had the boldness to enter on the project.

The Thames Tunnel (Figs. 1316, 1317, 1319, 1320, 1321, 1322, 1326) was but the carrying out of an idea which had been long before entertained. Mr. Ralph Dodd planned a tunnel under the Thames from Gravesend to Tilbury at the latter end of the last century. In the early part of the present century another engineer, not discouraged by the failure of this attempt, planned a tunnel under the Thames at Rotherhithe, a little below the site of the present tunnel; but, after a great expense of time and trouble, this also was abandoned. At length, in 1823, Mr. (now Sir Mark Isambard) Brunel brought forward the project of a Thames Tunnel: his object was not a new one, but his mode of proceeding was new, for he proposed to cover the miners with a peculiar kind of shield while at work; and the ingenuity of the idea drew the attention of many scientific men to the subject. In 1824 a company was formed, and an Act of Parliament obtained. According to Brunel's plan the tunnel was to go under the Thames from Wapping to Rotherhithe, as shown in the plan in Fig. 1322, and in the elevation in Fig. 1321.

Operations were commenced by making borings beneath the bed of the Thames, to ascertain the nature of the soil. It was found that there was a pretty stiff bed of clay immediately below the water, and that beneath the clay was a quicksand, full of water derived from landsprings; and it therefore became necessary to bore the tunnel through the clay, as close to the bottom of the river as safety would permit. To get down to the proper level for the excavation of this tunnel it was necessary to sink vertical shafts on either shore; and the construction of the shafts was among the most remarkable of the early operations. A cylinder of brickwork, a hundred and fifty feet in diameter, forty-two feet high, and three feet thick, was built up on the level of the ground. Excavators then got within this cylinder, and actually dug away the ground from beneath it, so that the huge cylinder sank inch by inch into the heart of the ground. This sinking was continued until the bottom of the cylinder was sixty-five feet below the level of the ground—the bricklayers increasing the height of the cylinder by new layers of bricks as the sinking proceeded. One cylinder on each shore, formed in this way, constitutes the vast space down which a passenger passes by a winding staircase to gain access to the tunnel.

The shaft being constructed, and arrangements made for drawing out the excavated soil and pumping up the water that might enter, the perforation of the tunnel itself commenced on the Rotherhithe side of the river. The tunnel was to be thirty-eight feet wide by about twenty-two feet high; and the difficult problem was, to excavate this through clay in such a manner that the roof should not fall in by the pressure of the river above before the bricks and masonry could be applied to it as a lining. Brunel adopted for this purpose a vast frame which he called a "shield"—regarded by every one as among the most admirable and ingenious contrivances ever devised for a specific purpose.

The shield is shown in three different points of view in Figs. 1317, 1319, and 1326; and an idea of the mode in which the men excavated the tunnel by means of this shield is also given in Fig. 1320, which supposes a vertical section to be made, lengthwise of the Thames and crosswise of the Tunnel. The shield consisted of twelve massive frames of iron, placed side by side, and capable of being slid forward for a small distance independently of each other. The flat soles at the bottom of the shield supplied a fair base, which might be readily slid forward; and the top and sides were securely closed in by flat plates, which, being supported by massive framing and fitting close to the brickwork, effectually prevented the falling in of the soft earth. Each frame of the shield consisted of three stories, each of which formed a cell large enough for one man to work in conveniently; and the front of every cell was protected by a series of narrow poling-boards, each of which was separately held in its place by an apparatus which allowed of its being fixed either on a vertical line even with the face of the shield, or a few inches in advance of such line.

The mode in which the miners work in the shield is thus described in 'London,' No. 54:—"We will suppose that the work being finished in its rear, an advance is desired, and that the divisions are in their usual position—the alternate ones a little before the others. These last have now to be moved. The men in their cells pull down the top poling-board, one of those small defences with which the entire front of the shield is covered, and immediately cut away the ground for about six inches. That done, the poling-board is replaced, and the one below removed, and so on until the entire space in front of these divisions has been excavated to the depth of six inches. Each of the divisions is now advanced by the application of two screws—one at its head and one at its foot—which, resting against the finished brickwork, and turned, impel it forward into the vacant space. The other set of divisions then advance. As the miners are at work at one end of the cells, so the bricklayers are no less actively employed at the other, forming the brick-walls of top, sides, and bottom; the superincumbent earth of the top being still held up by the shield till the bricklayers have finished. This is but a rude description of an engine almost as remarkable for its elaborate organization as for its vast strength. Beneath these great iron ribs a kind of mechanical soul really seems to have been created. It has its shoes and its legs, and uses them too with good effect. It raises and depresses its head at pleasure; it presents invincible buttresses in its front to whatever danger may there threaten, and when the danger is past again opens its breast for the further advances of the indefatigable host."

Skilful as was the arrangement of this shield, however, the progress of the tunnel was obstructed by disasters almost unparalleled for number and magnitude. It was in the beginning of 1826 that the excavation commenced; and the workmen had not proceeded more than ten feet before a watery stratum of sand gave them a pretaste of what they would have to encounter. In December of the same year the river burst into the tunnel, and a second time early in the following year; but the hole in both cases became filled up by the soil of the river-bed itself. Wherever the bed of the river was deemed weak, thin, or loose, bags of clay were thrown in from barges above to strengthen it. In May, 1827, the river broke in, and placed the lives of all the men in critical danger; three thousand bags of clay were thrown on the hole where the water had entered; and, after pumping out the water, operations were re-commenced. Sometimes earth or water burst in; sometimes impure air ignited and exploded; and at all times the atmosphere of the tunnel was so deleterious to the health of the workmen, that all suffered more or less. In August, 1828, a terrible irruption took place, which drowned some of the miners, and put a stop for the long period of seven years to the whole of the works; for the funds of the company were exhausted. In 1835 the government advanced money for proceeding with the works; and during two years the operations continued, but under difficulties of the most perilous and harassing nature, owing to the porous and saturated nature of the ground. In August, 1837, another irruption took place; in November of the same year another; and in March, 1838, another, which was the last that the engineer had to contend against.

At length, in August, 1841, Sir M. I. Brunel had the pleasure of seeing his great work brought to a conclusion, so far at least as concerns the foot traffic. According to the original plan, a gigantic spiral roadway, winding round a cylinder, was intended for horses and carriages, and the nature of this is indicated in some of the cuts; but this part of the plan has not yet been carried out: whether it ever will be, time must show.

DOCKS, DYKES, AND SLUICES.

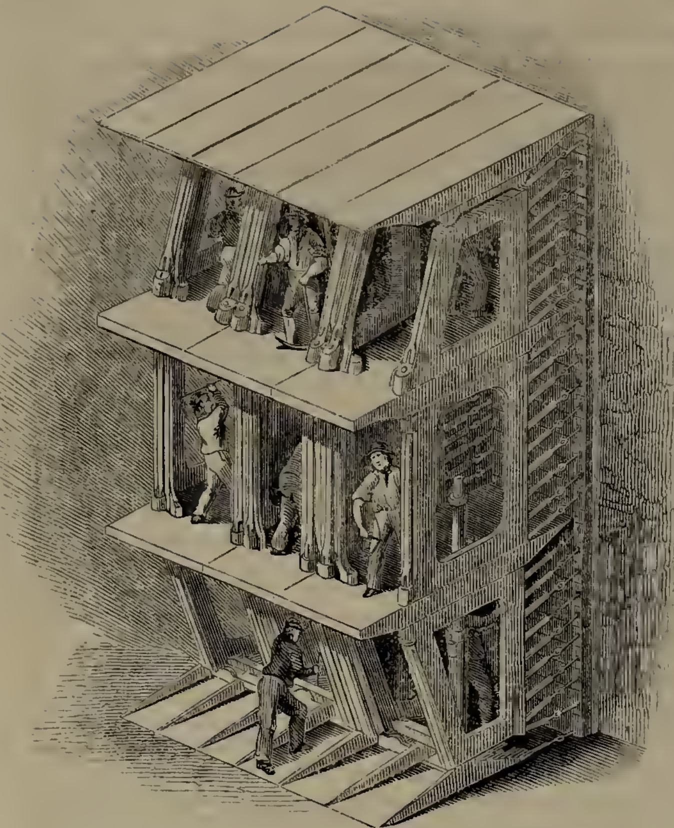
A large share of engineering talent is devoted to works which, in one or other of various ways, are intended to resist the action of water; either by forming a receptacle for the deposition of water, or by providing the means to stem the action of water.

Docks and Harbours.

The term "dock," as employed in a ship-building yard, relates either to a building-dock, which is kept dry during the time that a ship is on the stocks, or a wet-dock, for receiving ships and other floating bodies. The term is also applied to the whole of the buildings and arrangements of the Government arsenals, such as Plymouth Dock, Portsmouth Dock, &c. In a commercial sense a dock is a basin or deep receptacle, having stone quays or supports on all sides, and such a mode of connexion with a river or a sea, by means of gates and sluices, that it may have depth of water at all times sufficient to float large vessels. Sometimes a part of the sea-shore is walled in so as to form docks, while in other cases a river bank is treated in a similar way.

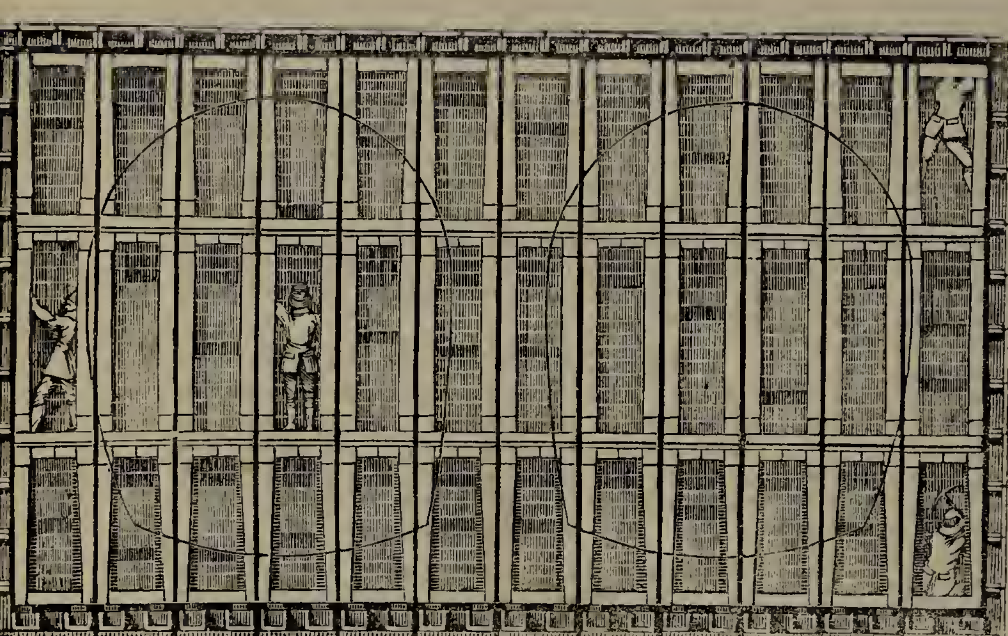
The docks of London furnish fine examples of the latter variety. Until 1558 there were no places specially appointed in the Thames for unloading goods from vessels; but in that year "legal quays" were established for this purpose, between Billingsgate and the Tower. Afterwards other quays, called "sufferance wharfs," were established from time to time; but it was not till about half a century ago that steps were taken to accommodate commerce more fittingly, by the construction of docks. One plan proposed was to deepen the Thames generally, and make quays along both of its banks; but the construction of docks was ultimately determined on, and gradually put in practice. Schemes poured in from all quarters; and those parties who had an interest in the continuance of the then-existing state of things, opposed them all; but the difficulties were removed by degrees, and many docks have been built.

The West India Dock was determined on in 1799, and opened for the reception of goods in 1802. In 1800 an act was obtained for the London Docks, and these were finished by 1805. In 1803 the act empowering the construction of the East India Docks was passed, and these docks were opened for business in 1806. So that, after so many years of consideration, there were three extensive systems of docks planned and executed within seven years. At later periods were constructed the Commercial Docks, the East Country Docks, the Surrey Canal Dock, and the Regent's Canal Dock. In 1825 another act was obtained for the con-



1317.—Excavating the Tham s Tunnel : diagonal view.

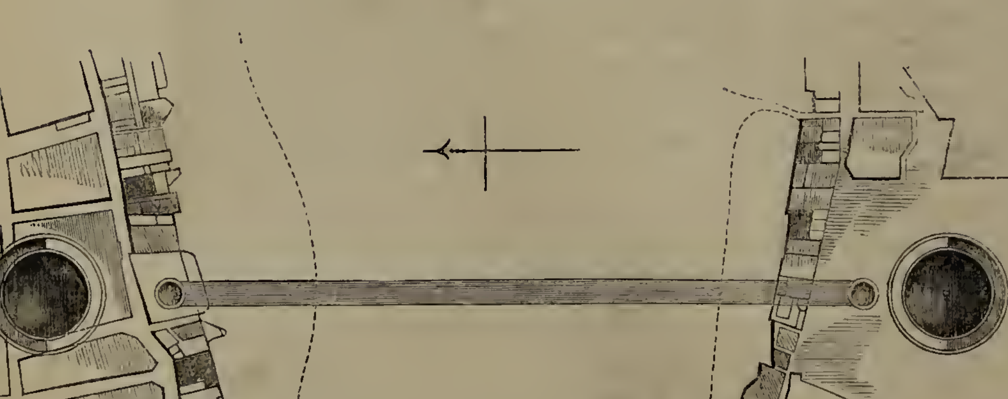
1318.—St. Katherine's Docks.



1319.—Excavating the Thames Tunnel : front view.

1320.—Relative Positions of the Thames Tunnel and the River.

1321.—Longitudinal Section of the Thames Tunnel ; with the double approaches as originally planned.

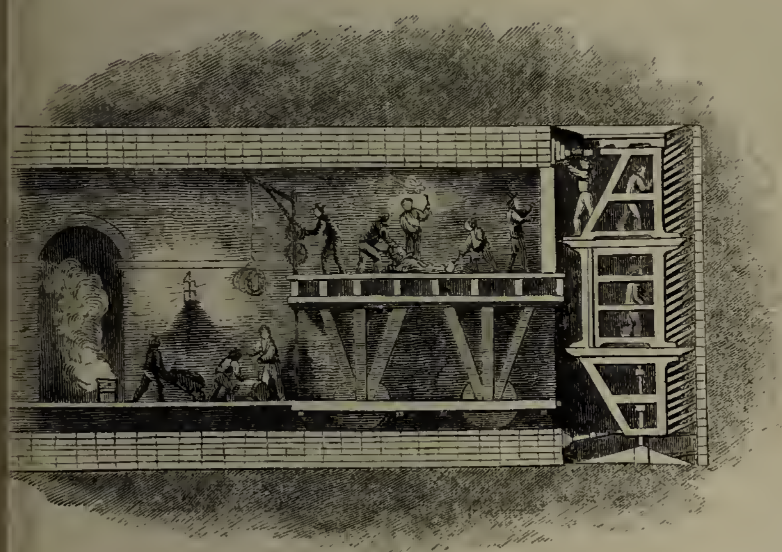


1322.—Plan of the Thames Tunnel and Approaches.

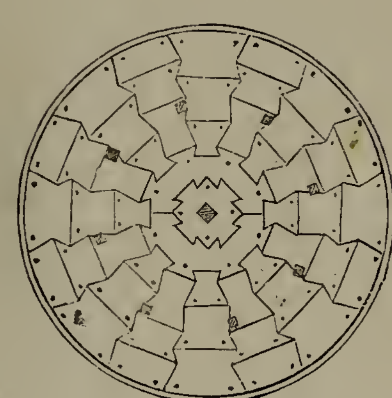
1323.—East India Export-dock, and Masting-house.

1324.—North Foreland Lighthouse.

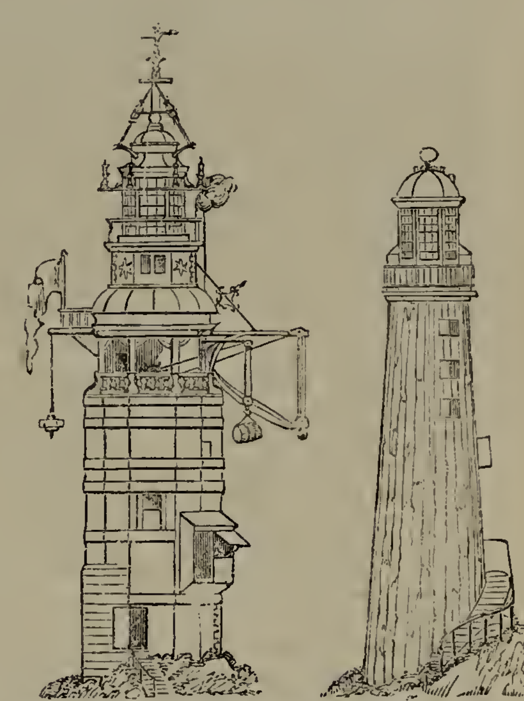
1325.—Dykes of Holland: destruction by bursting.



1326.—Excavating the Thames Tunnel: side view

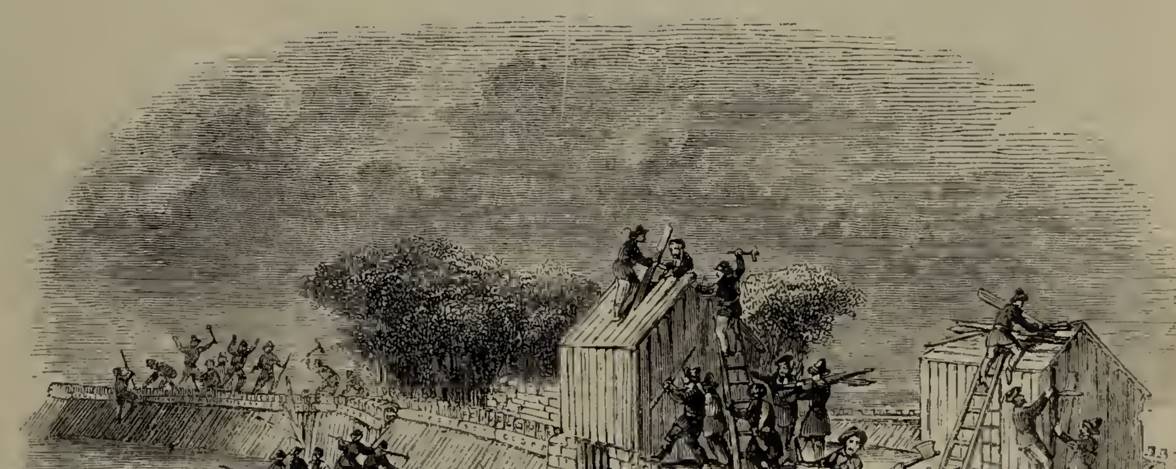


1327.—Masonry of Eddystone Lighthouse.



1328.—Winstanley's and Rudyerd's Lighthousse at the Eddystone.

1329.—Winstanley's Lighthouse at the Eddystone.



1330.—Dykes of Holland: destruction during war.

struction of St. Katherine's Docks; the works of which required the destruction of no fewer than eight hundred houses and a church. The works were carried on with great rapidity, and the docks were opened in 1828.

The London Docks (Fig. 1313) comprise an area of one hundred acres, and can accommodate five hundred ships. The warehouses are capable of receiving two hundred and thirty thousand tons of goods; the tobacco warehouses cover five acres, and can contain twenty-four thousand hogsheads of tobacco; the wine and spirit vaults are yet larger, and can accommodate sixty thousand pipes of wine. The West India Docks (Fig. 1315) (including a canal across the Isle of Dogs, now used as a timber dock) cover an area of nearly three hundred acres. The docks comprise, besides the timber dock, two others, known as the "import" and the "export." On one occasion the value of the commodities within the walls of the docks was upwards of twenty millions sterling, comprising principally sugar, coffee, rum, and timber. The East India Docks were formerly held by the Directors of the East India Company; but since the opening of the East India trade they have been purchased by the West India Dock Company: they comprise two docks, the "import" (Fig. 1314) and the "export" (Fig. 1323); but they are very much smaller in extent than those of which we have before spoken. The St. Katherine's Docks (Fig. 1318) are much smaller than the London Docks, but being arranged more skilfully they accommodate an immense amount of shipping and warehoused merchandise, and are in every respect well adapted for the object in view.

If we transfer our attention from London to Liverpool, we find a vast and extensive system of docks, of which some idea may be furnished by Fig. 1310. In the year 1708, the commerce of Liverpool having risen to a respectable position, the corporation thought it desirable to construct a dock, which they did at the spot now occupied by the Custom-house. From time to time other docks were added, by enclosing portions of the shore of the River Mersey with stone walls, until at length the docks amounted to eleven in number, occupying an area of a hundred acres, and extending along the whole length of Liverpool, fronting the Mersey just before that river enters the sea. The whole of the docks are managed by a committee, formed of some members chosen from the corporation, and some chosen from the merchants.

Birkenhead, until recently a very insignificant town, situated opposite to Liverpool on the south-west shore of the Mersey, bids fair to present in the course of a few years a series of most magnificent docks. There is a sheet of water, or a kind of small shallow bay, near the town, called "Wallasey Pool," which is now being converted into docks; and when these docks are finished, they will present an area larger than that of all the Liverpool docks put together. There will be a floating dock of a hundred and twenty acres; a tidal harbour of forty acres; a harbour of refuge of ten acres; and dock-accommodation of other kinds.

In all such engineering works as those here alluded to, there are involved such operations as the formation of coffer-dams and piers, the building of walls, the deepening of the ground, the construction of gates and sluices, the formation of flat stone quays on the brink of the water, and other labours in which the power of resisting water is a quality which must be added to the other excellences of the works.

The Dykes and Sluices of Holland.

Marine engineering is nowhere more curiously shown than in Holland, where great precautions are necessary to prevent the sea from inundating the land. Along the shore is a range of low sandhills, through gaps in which the rivers find an outlet to the sea. Behind these low hills a great part of the country is actually below the level of the sea at high tides; so that the inhabitants are at the mercy of the sand-barriers which intervene between them and the sea. The whole country, in fact, occupies what was once probably the vast mouth of the Rhine and other rivers, and the dry land is formed from the accumulating deposits brought down by those rivers from the German mountains. The country thus requires to be protected on the one hand from the encroachments of the sea, and on the other from the overflowings of the numerous branches into which the Rhine divides before finally joining the German Ocean. This shelter is afforded by sandhills and by dykes; the whole of the latter of which, and some of the former, are the work of the industrious and indefatigable inhabitants of the country. The dykes are strong and massive wooden structures, formed of piles embedded deeply in various directions in the ground, and rendered impervious to water by various means.

So imminent is the danger to which the Dutch would be exposed if anything were to go wrong with their dykes, that there is a permanent administration appointed, called the "*waterstaat*," whose office is to see that the dykes are kept up and the land protected against the inundations which are likely to occur several times in the year—at some seasons from the sea and at others from the Rhine. Obliged to watch their dykes, sluices, and waterworks, almost with the same attention as a garrison defend a besieged town, this body of men is always ready and always efficient. From the port of Ostend, north-eastward to the Zuider Zee, the whole coast, several hundred miles in length, is so near the level of the sea, that a high tide would be a perilous event for the Hollanders, were not every foot of this distance watched and barricaded, except, of course, at the points where the rivers enter the sea. The duty of watching and repairing such an extensive system of works, therefore, becomes a very onerous one.

It seems at first thought hardly credible that works, constructed with such untiring industry and for such an excellent purpose, should be designedly destroyed during times of war; but when we find how unscrupulous are the means whereby an opposing army will carry misery into the attacked country, we may be prepared to understand how it is that "sluice-breaking" has been a mode of attack to which Holland has been subjected. The scene represented in Fig. 1330, copied from a Dutch print, relates to one of these unworthy exploits of sluice-breaking, which occurred in the last century. More generally, however, any destruction of the dykes or sluices has been the work of the sea or the rivers. Fig. 1325, for instance, represents a terrible scene which took place in the year 1651, when a part of the artificial rampart near Amsterdam, called St. Anthony's Dyke, gave way, during a very unusual high-water flood. The water burst in through the opening with irresistible fury, and covered the country around Amsterdam to the depth of thirty feet.

The most serious results from the bursting of these dykes, however, took place in the year 1825. In the early part of that year storms of an extraordinary character occurred throughout nearly the whole of the district through which the Rhine flowed in its course towards Holland; and everywhere there were great devastations committed by the overflowing of the water from the swollen river. "The people of Holland," it has been said in an account of this event, "heard these accounts with dismay, particularly the intelligence of the ravages committed by the Rhine in the upper part of his course. In his irresistible fury he had overleaped or demolished his embankments a thousand feet above the level of the sea; and what might not be dreaded from the force of his accumulated water descending on the Dutch territory, the highest point of which is only about thirty-two feet above the same level! The height of their dykes and causeways along his banks is not more than twenty-four feet; and if the water exceeded their elevation, their wealthiest towns and most prosperous villages must have been overwhelmed in one common ruin. The water in most places had actually ascended to the top of the dykes. In some parts of the country these ramparts threatened to yield; in others they had even been slightly broken: every stream was covered with wrecks; every canal leaned against tottering embankments."

This occurred about Christmas 1824; but happily a wind suddenly sprang up which drove the accumulated waters of the Rhine out into the sea, just before they seemed about to burst over the devoted country. During the ensuing six weeks the inhabitants were busy in repairing the damage done to the dykes. But the security was not of long continuance. In the early part of February, an unfavourable wind, for three successive days, acting in conjunction with an unusually high tide, raised the waters to such a height, that the dykes were burst, and some of the fairest portions of the country inundated. "In East Friesland and Overyssel, especially, the inundation was terrific, and the damage immense. Out of the thirty-two lordships of which the former consists, only five escaped the flood. The rest were all partly or entirely overflowed, and more than one hundred thousand acres of their most fertile land converted into a salt-water lake. The flood in this quarter rose four feet above the dykes, and poured in upon the country below in a continuous stream. It was impossible to resist, and difficult by the most rapid flight to escape its fury. Men, cattle, and every living thing fell a sacrifice to its rage. In many of the villages and farm-steadings not a house was left standing, nor was a head of cattle saved. The number of men who perished in the water, or were crushed to death by their falling houses, amounted to about one hundred. In one lordship only the number of black cattle drowned amounted to more than a thousand. In some places the villages and churches were raised a little above the level of the fields and meadows; thither the peasants, therefore, ran for safety. In the church of the village of Wolvega, for instance, four hundred of these wretched beings took refuge from the surrounding flood, without being able to carry with them a single article of food or rag of clothing, and remained benumbed with cold or perishing with hunger till the arrival of means of relief."

The *sluices*, alluded to in some of the foregoing paragraphs, are gates which are capable of being closed or opened by means of hinges or other contrivances, so as to permit or to prevent the flow of water at pleasure. They are pretty much the same as "flood-gates," being applied to canals, to mill-streams, to ponds, and to other collections of water, the flow of which it is desired to keep under control. A sluice of a very complete kind, as used in some parts of Holland, is sketched in Fig. 1308. In some cases, where a sluice divides a river from the sea, it is required at one period to resist the inward pressure from the sea, and on another the outward pressure from the canal or river, according as the one or the other may happen to be the greater. Supposing A and B to be two parts of this river or canal, separated by the flood-gates *b*. When it is required to stem back a head water from A, the two upper channels (marked by dotted lines, and leading from A) are opened, whereby water is admitted into the two receptacles *d d*: the rush of this water closes the gates, and attains the object in view. Supposing, however, that water is to be stemmed back from B, then water is admitted into the receptacles through the lower channels from B, and exerts a force more than sufficient to counteract the pressure against the gates; since the surface of sluice-gate acted on by the water in *d* is rather larger than that acted on by the water in B.

The Diving-Bell, as used in Submarine Engineering.

It must have puzzled many readers, whose attention has been devoted to engineering matters, to determine how masonry and other works can be carried on under the surface of the water, in circumstances where the "caisson," or the "coffer-dam," could hardly be used. When, for instance, Mr. Walker wished to ascertain the precise state of the piers of Blackfriars Bridge, previous to the repairs; or when Brunel wished to know what was the condition of the bed of the river after one of the irruptions into the Thames Tunnel—how did they make their examinations under the surface of the water? It is in such cases that the *Diving Bell* becomes of immense value.

A diving-bell is a hollow metal chamber, let down into the water in such a manner that a considerable body of air remains in the chamber, and prevents it from becoming quite filled with water. If a man be seated in this chamber or bell in such a manner that his head be above the level of the water, and if means be provided for pumping out the respired air and replacing it with fresh, then the first important stage in the operation is attained.

Generally speaking, a diving-bell is thus arranged:—It is a cast-iron box about six feet long, nearly as much in width, and four or five feet in height. The metal is thick enough to resist fracture, and heavy enough to sink in the water. The bell is open at the bottom, and closed everywhere else, with the exception of certain openings having a definite object in view. One of these is a round aperture at the top, communicating by a number of small holes with the interior, where the holes are all covered and closed by a piece of thick leather, which acts as a valve and admits air. A strong leather hose is screwed to the external aperture; and from two holes near its sides rise two strong chains uniting in a ring, by which the whole machine is to be suspended. In the top also are fixed several thick lenses, to admit light to the interior of the bell. At the ends of the bell are two seats, placed at such a height that the head of the sitter reaches nearly to the top of the bell; and in the middle is a narrow board on which the feet of the sitters rest. A small shelf is provided, on which any articles for the use of the divers are placed; among which are a board and a piece of chalk to write any message to the men above, and a rope for conveying this board up to the surface of the water. The bell is suspended and lowered by strong tackle; and an air-pump, worked by four men, keeps up a constant interchange of air in the bell, through the medium of the leathern hose.

A diving-bell on a very complete plan is sketched in Fig. 1353. The bell is suspended by strong ropes, which join to form one of large diameter. At the bottom edge are ballast weights, to keep the open mouth of the bell always parallel. The bell can be made either lighter or heavier than an equal bulk of water, by the use or not of the heavy weight suspended at the bottom; and this gives the divers a command over the ascent and descent. The diver stands on a rope net-work stretched across the bottom of the bell. Suspended at the two sides are two air-casks, each containing forty gallons of fresh air; and there are pipes and valves for admitting fresh air and expelling foul. The conical summit of the bell is a very ingeniously constructed bell of smaller size, surmounted upon the lower one; and the diver has the means of keeping this upper bell filled either with air or with water at pleasure; whereby he is enabled to raise himself, to sink lower, or to remain at any desired depth in the water.

The sensation experienced by the diver is thus described by Mr. Babbage:—"On touching the surface (of the water), and thus cutting off the communication with the external air, a peculiar sensation is perceived in the ears; it is not, however, painful. The attention is now directed to another object: the air rushing in through the valves at the top of the bell overflows, and

escapes with a considerable bubbling noise under the sides. The motion of the bell proceeds slowly, and almost imperceptibly; and on looking at the glass lenses close to the head, when the top of the machine just reaches the surface of the water, it may be perceived, by means of the little impurities which float about in it, flowing into the recesses containing the glasses. A pain now begins to be felt in the ears, arising from the increased external pressure; this may sometimes be removed by the act of yawning, or by closing the nostrils and mouth, and attempting to force air through the ears. As soon as the equilibrium is established the pain ceases, but re-commences almost immediately by the continuance of the descent. On returning, the same sensation of pain is felt in the ears; but it now arises from the dense air which had filled them endeavouring, as the pressure is removed, to force its way out. If the water is clear, and not much disturbed, the light in the bell is very considerable; and even at the depth of twenty feet was more than is usual in many sitting-rooms. Within the distance of eight or ten feet, the stones at the bottom began to be visible. The pain in the ears still continued at intervals, until the descent of the bell terminated by its resting on the ground."

There is a waterproof diving dress very frequently employed, similar in some of its features to the smoke-proof fireman's dress, of which we shall speak a page or two onwards.

LIGHTHOUSES, SIGNALS, AND TELEGRAPHS.

A VERY interesting department of civil engineering is that which relates to beacons or signals, whether in the form of a light to guide mariners at night, or a signal or telegraph to convey a written direction to a great distance. The former of these belong especially to engineering, whereas the latter relate more nearly to mechanical ingenuity on a smaller scale.

Lighthouses: their Form and Construction.

Where a lighthouse is built upon land it requires to be simply a building strong enough to bear winds and ordinary sources of injury, and lofty enough to exhibit a light which shall be visible to a considerable distance; but where it is built on a rock in the sea, difficulties of a most momentous kind result.

The North Foreland Lighthouse (Fig. 1324) is of the former kind. The North Foreland is a promontory on the Isle of Thanet, and is so situated with respect to the dangerous "Goodwin Sands" as to render the erection of a lighthouse on that spot very advantageous to mariners. Two centuries ago there was a lath and plaster house existing on this spot, with a lantern to serve as a beacon; but about half a century afterwards a stronger building was erected, which was afterwards altered to the present form. It is simply a strong building, high enough to render the light, which is always burning in the night time, visible to a distance of twenty or thirty miles.

The Eddystone Lighthouse is an example of the opposite kind, where the structure has to be erected on a rock in the midst of the sea. A few of the difficulties incident to such specimens of engineering were alluded to in the opening page of this chapter, and a few other illustrations may here be given.

The Eddystone Rock is situated about fourteen miles from Plymouth. It is above the level of the sea at low water, but beneath it at high water; and, being situated at a spot very likely to be traversed by a ship entering Plymouth Harbour from the Atlantic, it became by degrees a very perilous obstacle. Many proposals were made—not to destroy the rock itself, but to build upon it a beacon which should warn mariners from approaching. The first person who entered seriously on this matter was Mr. Winstanley, an Essex gentleman, who was an engineer for pleasure, and not by profession, and who contrived a number of curious mechanical knick-knacks. He commenced building a lighthouse on the Eddystone Rock in 1696, and finished it about 1700. It was an odd-looking structure, decked out with trappings not much calculated to add to its strength (Fig. 1329, and left hand of Fig. 1328). It was a polygonal building of stone, about a hundred feet in height. Winstanley had great confidence in the strength of his building; but on the 26th of November, 1803, a terrible tempest destroyed it so completely that not a single fragment of the building remained standing.

The next lighthouse was built on the Eddystone by Mr. Rudyerd, "a silk-mercer on Ludgate Hill," who seems to have had a mechanical turn of mind: he commenced operations in 1706, and finished in 1709. His lighthouse (right hand of Fig. 1328) was built of wood, was circular, and about ninety feet in height. This lighthouse, though rather rude in construction, was very creditable to the skill of Rudyerd; for it bore the buffetings of storms and tempests during a period of nearly half a century, and was at length destroyed—not by the sea, but by fire.

Smeaton was employed to build the third Eddystone Lighthouse, the one which still remains, after an existence of eighty-five years, as a monument of his skill. To show the extraordinary difficulties attending the working on a rock which is alternately above and below the surface of the sea, it may be stated that, although the construction took two years and a half of time, the workmen were at work on the rock only a hundred and eleven days! The lighthouse is of stone (Figs. 1333, 1343); and although the waves often, in a violent storm, wash completely over it in one huge sheet, the masonry has never been disturbed. This is attributable mainly to the extraordinary precautions taken to link the stones so closely together that one can hardly be loosened from the other. A part of the upper surface of the rock was chiselled, or hewn away, so as to form a flat surface; and six foundation courses of masonry, dovetailed together, were then raised on the lower part of the rock: these courses, with eight others raised above them, form the solid bed of the work, and take the form of the swelling trunk of a tree at its base. The "dovetailing" here spoken of, or mode in which the stones are made to wedge in one among another, is shown in the ground-plan sketched in Fig. 1327. The successive layers of masonry are strongly cemented together, and connected by oaken trenails, or plugs, and strongly cramped. Most of the stones employed varied from one to two tons in weight.

The Bell Rock Lighthouse, and others which have been constructed on various parts of the coast, have presented engineering difficulties approaching more or less to those of the Eddystone; but in most cases the degree of difficulty has been intermediate between that which we have just considered, and that involved in such a simple structure as the North Foreland Lighthouse. There have, however, within the last few years, been some curious engineering exploits connected with lighthouses. A cast-iron lighthouse, wholly planned and made within the almost incredibly short space of three months, has been erected in Jamaica: the building being a hollow shaft made of curved iron plates, riveted together. Another ingenious contrivance is Mr. Mitchell's "screw-pile lighthouse," in which the whole structure actually rests on eight or ten poles *screwed* into the soil at the spot where it is erected; so that the waves are allowed to wash freely between the foundation on which the light-room above rests. This form of lighthouse was planned for use where the soil is a loose sand, and therefore unfitted for the reception of solid masonry. A lighthouse of this kind has been erected near Fleetwood, at the mouth of the river Wyre. Captain Bullock, Mr. Bush, and several other engineers, have tried to erect something like a fixed beacon on the Goodwin Sands; but the shifting nature of the sand is such that only partial success has as yet been attained. Another curious undertaking has been the actual removal of a lighthouse from one spot to another, without injuring the structure as a whole: the mode of effecting this was described in page 159.

Lighthouses: their Lights, Lenses, and Reflectors.

Thus far we have spoken only of the building which is to contain the light; but we have next to consider the light itself. Few persons who had not entered on the subject would imagine how varied have been the lights employed for this purpose.

In ancient times open fires were kindled either on sea-side hills, or on buildings constructed for the purpose, as a beacon for mariners. When lighthouses were first used in England various modes of lighting were from time to time introduced. For instance, there was a large glass lantern placed on the top of the first North Foreland Lighthouse; but in the early years of the use of the present structure there was an iron grate quite open to the air, in which a good fire of coals was kept blazing all night. After this, when the top of the building was enclosed, attendants were employed to blow the fire throughout the entire night, as a means of keeping up the blaze. At a later period the fire was altogether dispensed with, and lamps, reflectors, and lenses substituted in its place.

The Eddystone Lighthouse was lighted with candles down to about the year 1811, twenty-four candles being employed for this purpose. Until 1812 the Lizard Lighthouse presented only a coal fire. The Bidstone Lighthouse, near Liverpool, had an enormous oil-lamp, with a wick twelve inches in width. Thus fires, candles, and large smoky lamps, without any aids to increase the illuminating power of the flame thus produced, continued to be employed for all lighthouses until the present century was much advanced; since which times many improvements have gradually been introduced.

One of these was the invention of the Argand lamp. This lamp (as was explained in page 71) gives, with a given expenditure of oil, a much brighter light, with much less smoke than lamps on the old construction, and is, in these respects, better fitted for the purposes of a lighthouse. Another contrivance has been the use of a reflecting mirror, formed of some such material as the speculum of a reflecting telescope. Such a mirror, worked into the parabolic form, and placed behind the flame of a lamp, reflects the light of the lamp with great intensity in one given direction. But a peculiarity results from the use of such a contrivance. The reflector does not actually *increase* the quantity of light yielded by the lamp, but it condenses or strengthens the light in one particular direction; and if the light were required only in this direction, and not at all in any other, then the use of the parabolic reflector would have reached its highest value. But in all cases the light of a lighthouse is required to have a certain width of range, much greater than can be given by the use of one fixed reflector. Hence it became necessary either to increase the number of lights and reflectors, and vary the angle at which they are placed; or to give a revolving movement to the light, so as to enable it to be seen in different directions at different successive instants. The latter plan has been extensively adopted, and is found very advantageous. The reflectors usually employed are made of copper, coated with silver.

According to the mode and extent to which this revolving system is employed the lights obtain different names. Thus a *stationary* light is one where the rotation is not employed, but where there is a series of metallic reflectors surrounding a fixed flame, at such an angle as shall reflect the rays to the most convenient points at the level of the sea. The *revolving* light is one in which the reflectors are fixed upon a frame, which revolves uniformly on a vertical axis, in such a manner as shall make the light alternate in brightness and dullness according as any one of the reflectors is or is not in a favourable position for reflecting the rays. A *flashing* light differs from the preceding principally in the circumstance that the reflectors revolve much more rapidly, so as to make the light appear to flash out very suddenly, and then be succeeded by an equally brief period of darkness. The *intermittent* light is another variety; in which alternation of light and darkness is so managed that the light remains visible for a minute and a half, and then disappears suddenly, remaining invisible for half a minute. All these are praiseworthy contrivances, instituted with a view to determine which are best fitted to attract the notice of a mariner, when anxiously looking out for some beacon of safety; each variety has its own peculiar advantages.

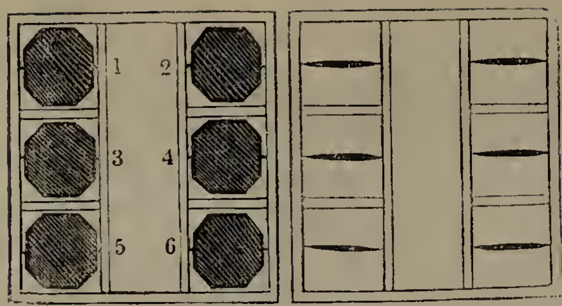
Considerable progress has been made in the adoption of *dioptric*, or *refracting* mechanism, instead of *reflecting*, in lighthouses: that is, optical arrangements in which the light is transmitted through a glass lens, instead of being reflected from a metallic surface, and thereby bearing the same relation to the former as a refracting telescope does to a reflecting one. While Smeaton was proceeding with the Eddystone Lighthouse a proposal of this nature was submitted to him, but it does not appear to have been acted on. The great loss of light occasioned by the use of reflectors, through the absorption of the rays at the metallic surface, led to the suggestion that the refractive power of a lens, which is not accompanied by so much absorption, might possibly be advantageous for lighthouses; and to the French is due the credit of having first put the plan into execution. A very powerful lamp, and a large glass lens, are required in this arrangement; but as a lens of large size must necessarily be of great thickness in the middle, and as this thickness would occasion a loss of some of the light, an ingenious mode has been adopted of building up a lens piecemeal, in such a manner that the focalizing power shall be retained, without such an extensive thickness of glass being employed.

It is probable that, even if one kind of light for a lighthouse should be found to be better than all the others, several different kinds would continue to be employed; because it is essential to the mariner not only that he should see the light from a distance, but that he should be able by some peculiarity or other to distinguish it from lights which might otherwise be confounded with it. Every particular lighthouse is connected, in his mind, with a particular set of rules as to latitude and longitude, bearings and soundings, rocks and shoals; and if, on seeing a light, he did not clearly recognise which one it was, it might be a beacon of destruction instead of safety to him. Hence the use of coloured and colourless, stationary and revolving, flashing and intermitting, reflecting and refracting lights. The two powerful lights known as the "Drummond" and the "Bude" light, described in Chapter III., have been proposed to be used for lighthouses; but difficulties of various kinds have hitherto prevented the suggestion from being practically carried out.

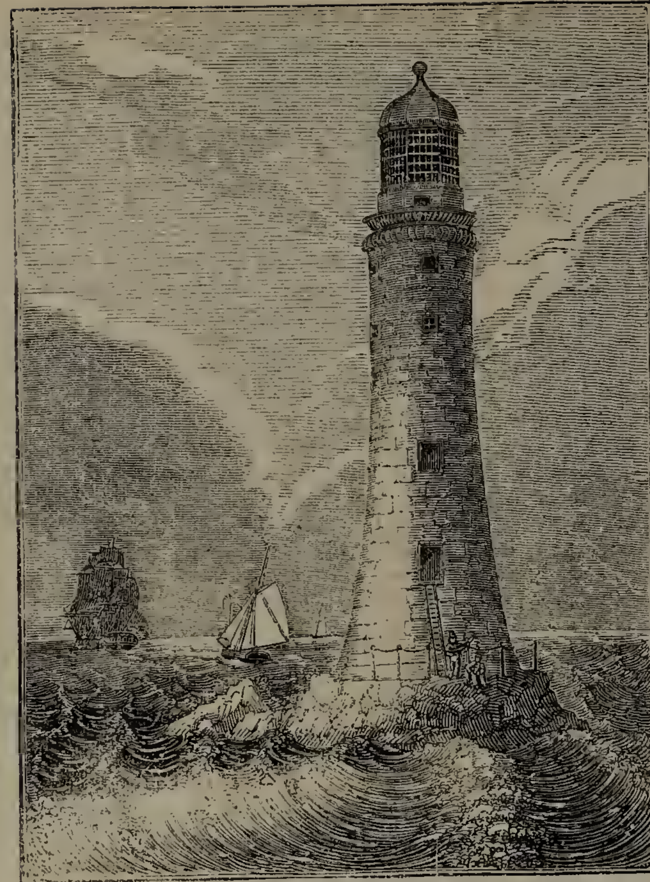
Signals and Telegraphs.

A lighthouse, from what has now been said, it will be seen, is merely a guide to show a mariner where he is to steer in order to avoid dangerous spots. The signals and telegraphs, however, used by so many different nations in so many different ways, have been intended for various purposes. Both for purposes of war and for those of peace, such contrivances often display much ingenuity.

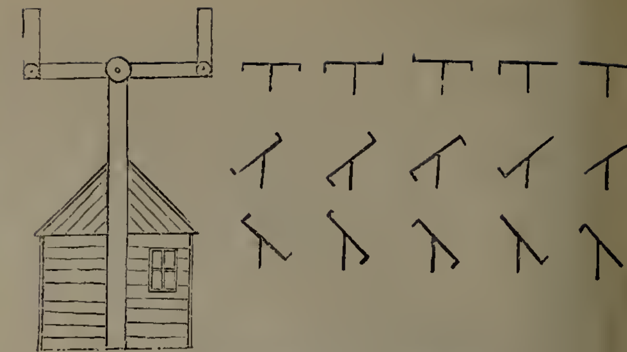
One of the simplest of all beacons or signals is a blazing fire or flame. The beacon-fires, used for giv-



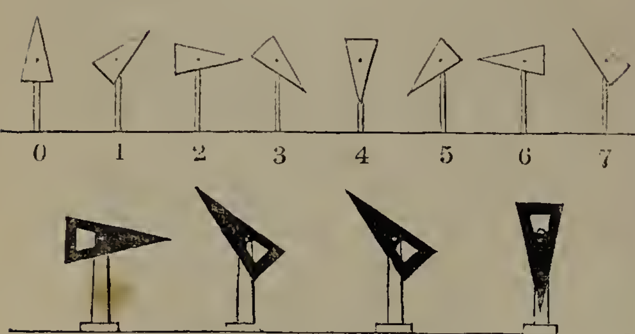
1331.—Telegraphic Signals.—Gamble's plan.



1333.—East side of the Eddystone Lighthouse.

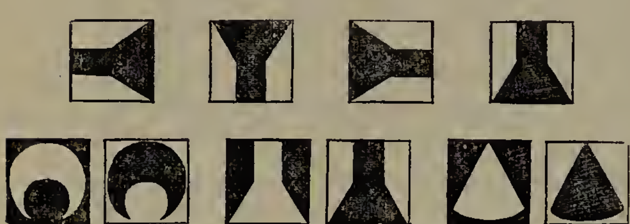


1334.—Telegraphic Signals.—Chappe's plan.

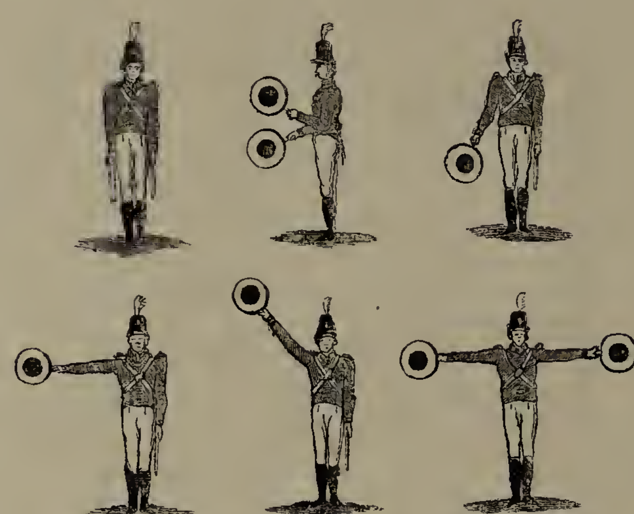


1332.—Telegraphic Signals.—Edgeworth's plan.

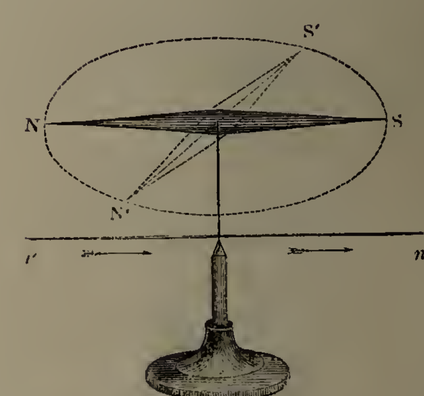
1335.—Telegraphic Signals.—Hooke's plan.



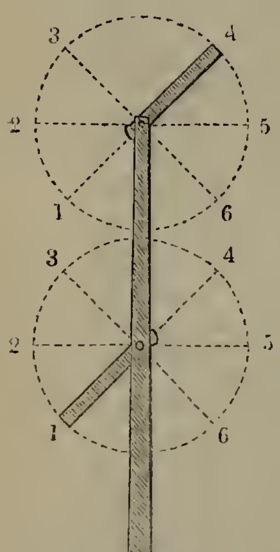
1336.—Telegraphic Signals.—Conolly's plan.



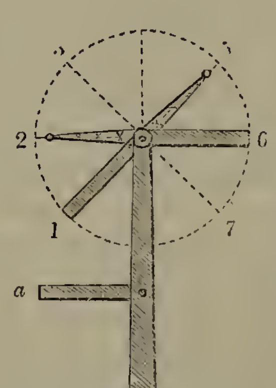
1337.—Military Telegraph.—Spencer's plan.



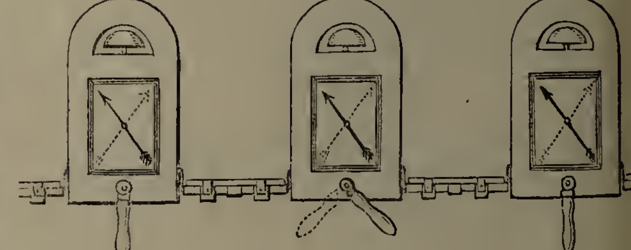
1338.—Magnetic Needle.



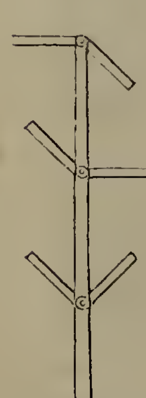
1339.—Telegraphic Signals.—
Popham's plan.



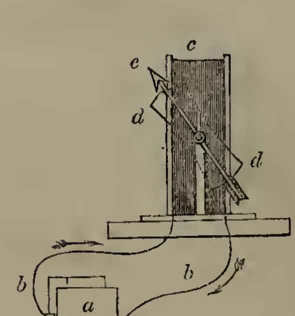
1340.—Telegraphic Signals.—
Pasley's plan.



1344.—Electrical Telegraph.

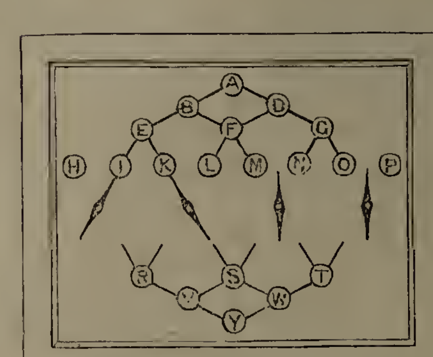


1341.—Telegraphic Signals.
Pasley's plan.

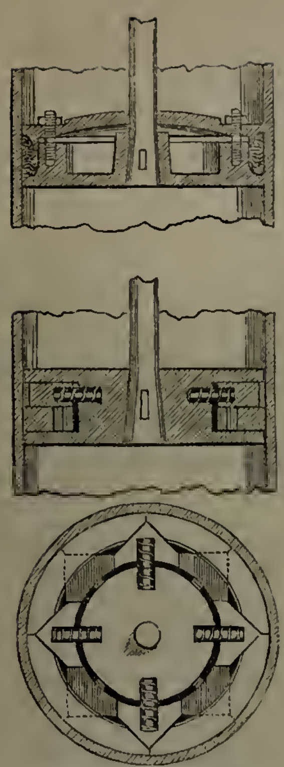


1342.—Electrical Telegraph.

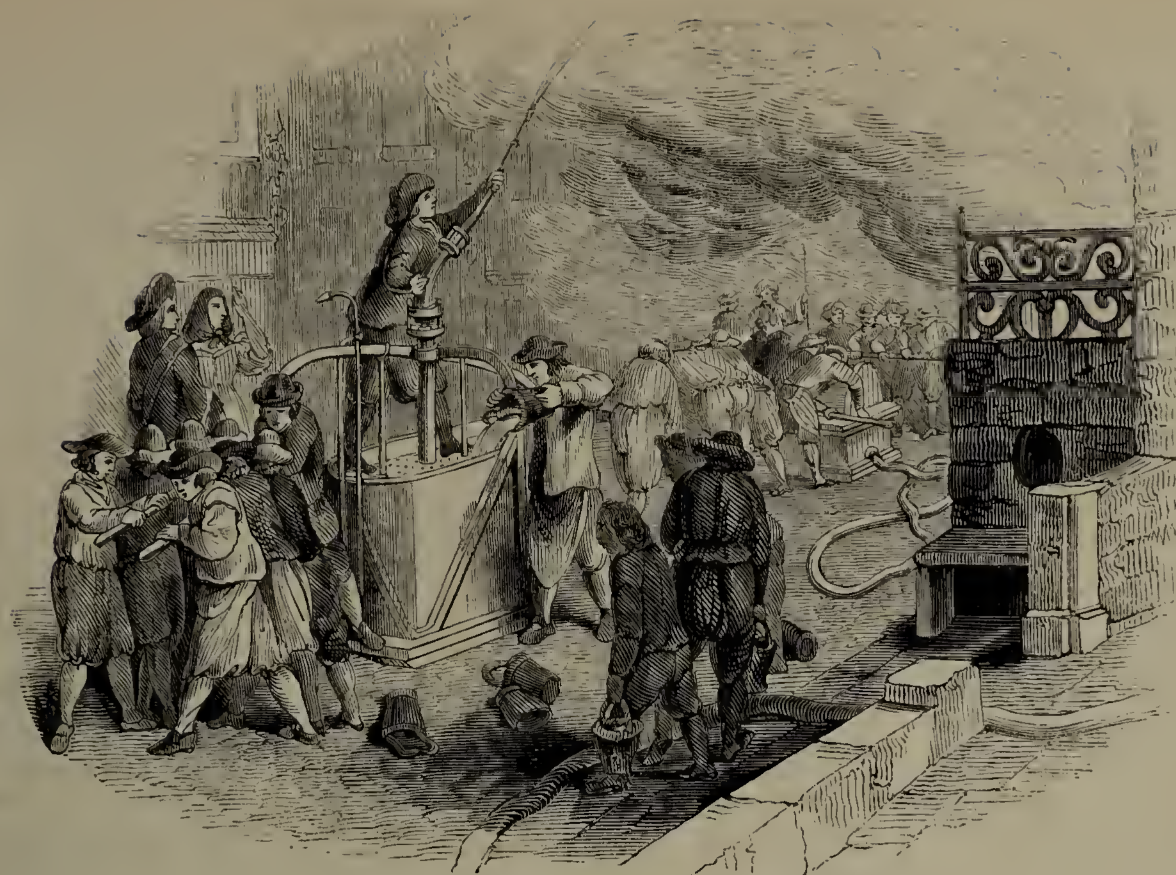
1343.—Eddystone Lighthouse in a storm.



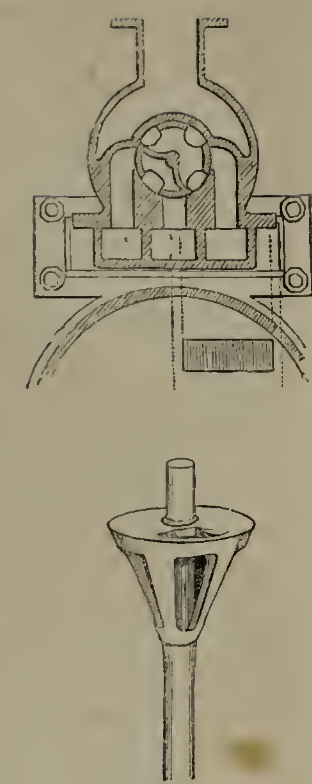
1345.—Electrical Telegraph.



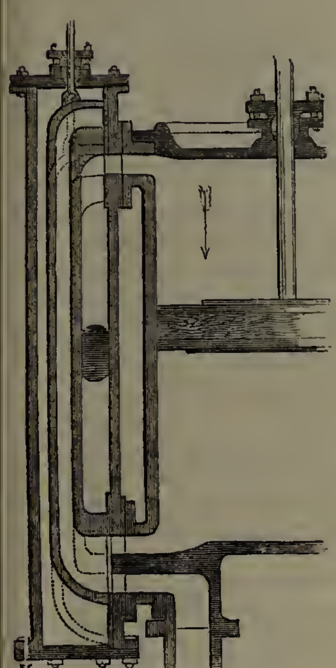
1346.—Steam-engine Apparatus.



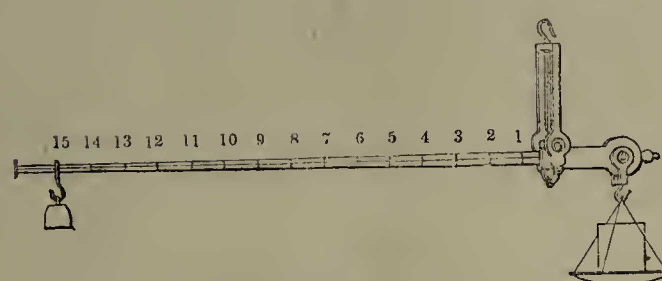
1347.—The first Fire-engine; used in Holland about 1660



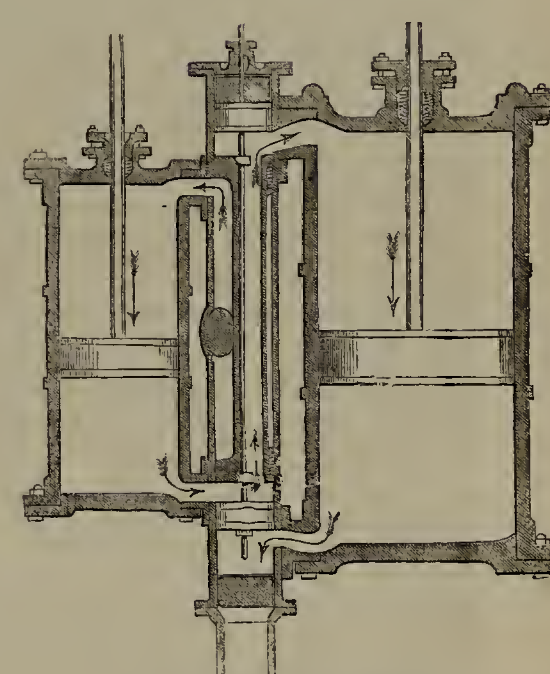
1348.—Steam-engine Apparatus.



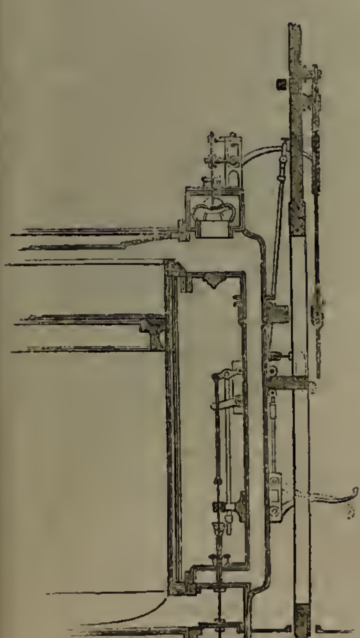
1349.—Steam-engine Apparatus.



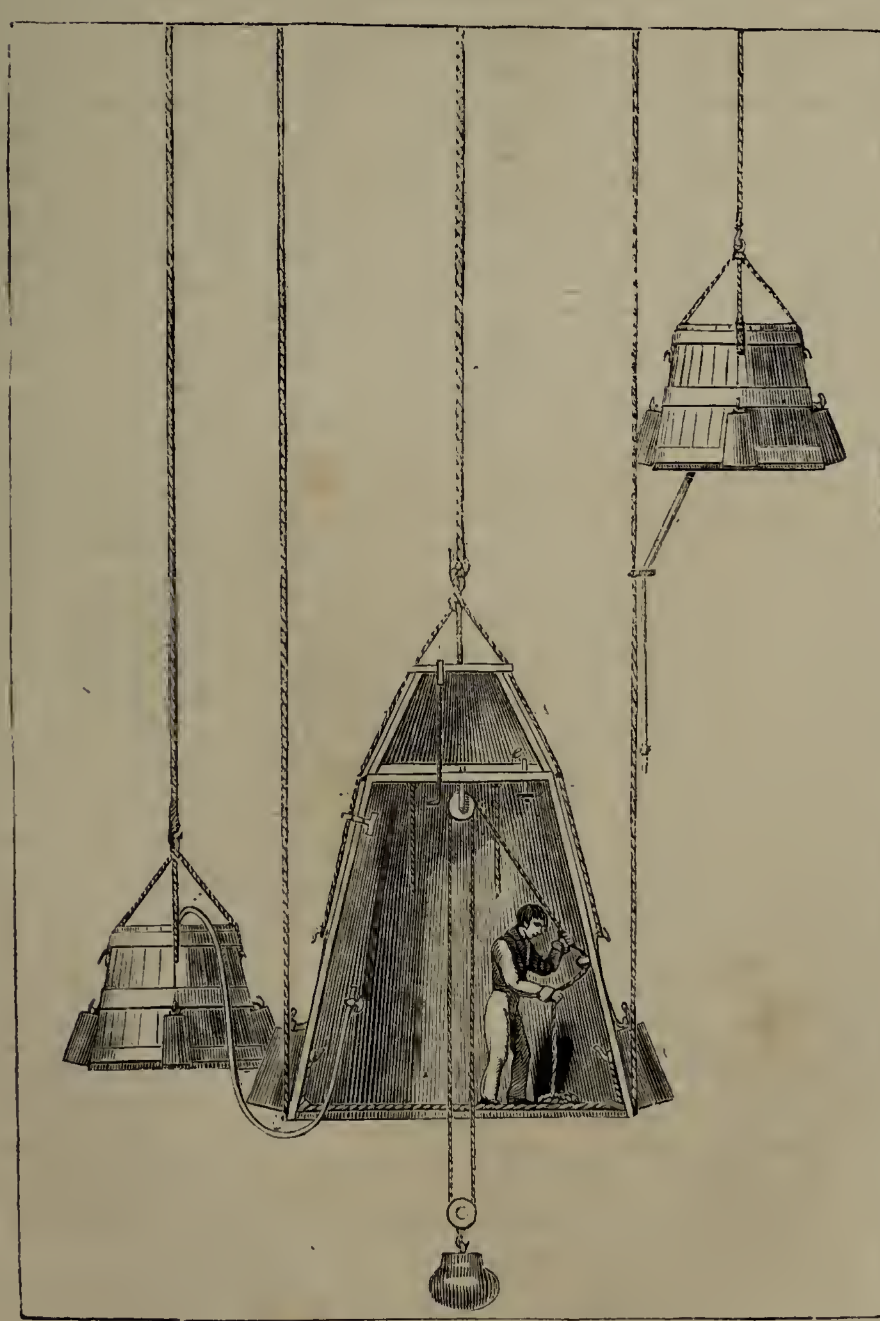
1350.—Steelyard.



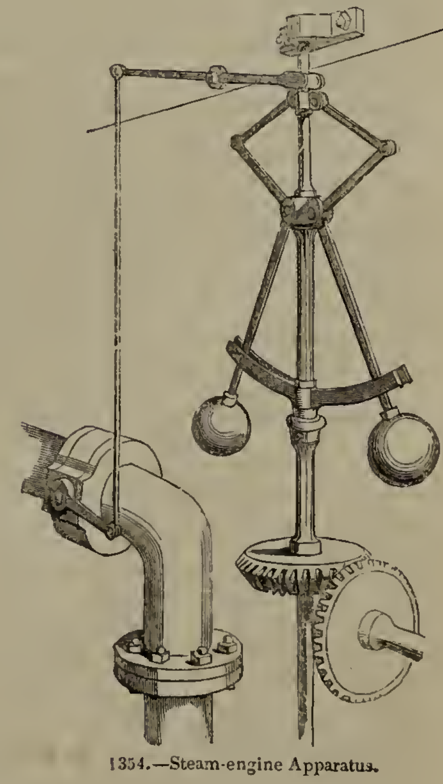
1351.—Steam-engine Apparatus.



1352.—Steam-engine Apparatus.



1353.—Diving-Bell, on Spalding's arrangement.



1354.—Steam-engine Apparatus.

ing warning of the approach of an enemy, are alluded to very frequently in Scripture, and also in the classical writers. There was a curious law in operation in Scotland about the year 1455, when hostilities were common between the English and Scotch, to the effect that one blazing faggot should be warning that the English were approaching, that two should intimate they were very near, and that three should signify them to be in great force. Torches held in particular positions in respect to each other, or alternately exposed and hidden, have also been employed as signals.

Besides those contrivances in which lights are employed, others, to an almost innumerable extent, have been devised; such as by the use of flags, rockets, trumpets, drums, gongs, the firing of guns, and visible writing by hieroglyphic, or short-hand characters. The use of several boards or levers in such a way that the relative positions of some or all of them shall represent preconcerted letters, words, or phrases, has been more adopted than any other contrivance; and a few examples of these will suffice for our purpose.

The scheme shown in Fig. 1335 was proposed by Hooke in 1684. There is a frame-work, of sufficient height to be seen afar off, supporting a screen; and behind this screen are thirty symbols, or characters cut out in wood, such as are shown in the cut; by drawing the handle *c* any one of these symbols may be drawn out from its hiding-place, and exhibited to view in the position *b*. The symbols are to represent letters, words, or sentences just as may be agreed upon by the two persons who may wish to correspond from a distance by this means. A plan, proposed by M. Chappe in France about 1793, is shown in Fig. 1334. There is an upright beam or post, rising from a small hut or observing-room below, and terminated at the top by a cross-beam; this cross-beam was pivoted to it so as to stand at any angle when worked from below by a rope; and the ends of the cross-beam were provided with two other beams still smaller than itself, and both capable of being brought into any position by means of pivots and guide ropes. The number of different relative positions into which the various pivoted pieces may be placed are almost endless: a few of them are shown on a smaller scale in the cut. Mr. Edgeworth devised a telegraph in 1794, in which certain pieces of board were to represent numbers (Fig. 1332), and these numbers were to refer to certain words and letters in a key or dictionary agreed on between the parties. A triangular piece of wood is mounted on the top of a staff, and so pivoted to it as to be able to take eight different directions, which represent the eight numerals from 0 to 7; other means being adopted to indicate 8 and 9. By having four such boards, side by side, the one may represent units, another tens, the third hundreds, and the remaining one thousands; and thus a very extensive numerical system may be established.

Mr. Gamble, about the latter end of the last century, proposed an arrangement in which five shutters, one over another, should represent signals according to the number and relative positions of those which were closed; and, after one or two modifications, the plan was adopted by the Admiralty, in the form shown in Fig. 1331. There was a frame-work containing six octagonal boards, so pivoted to the sides of the frame that these could assume either a vertical and visible position (as in the left hand half of the cut), or a horizontal and invisible position (as in the right half); or some could be in one position, and some in another. A dictionary was prepared in which certain letters and words were laid down as belonging to certain combinations among the shutters visible at any one time. There proved, in practice, to be a good deal of difficulty attending the use of the shutter-telegraph, and many propositions were made relating to new forms. One of these, suggested by Captain (now General) Pasley, is sketched in Fig. 1341. There is an upright pole or staff, with six small bars springing from it—three to the right, and three to the left—in pairs. Every bar is so pivoted as to occupy any one of several different positions, when governed by ropes from below: these positions, by being viewed in relation one to another, and referred to a catalogue, afforded the means of expressing words and sentences.

In 1816 the Admiralty determined on an alteration in the kind of telegraph adopted by them, and they substituted for the shutter-telegraph before in use a form suggested by Sir Home Popham. This form (Fig. 1339) consists merely of an upright post with two arms: the various signs, numerals, or letters of the alphabet being represented by the relative positions which the two arms are made to occupy. Thus, as in the figure, each arm is capable of assuming six different positions, sufficiently distinct one from another to render them all easily discernible. The arms when not in use are entirely enclosed in the hollow vertical post. The communication from beneath, whereby the arms are moved, is made by long spindles, terminated with a mechanism of toothed wheels at each end, instead of the ropes and other shrinking materials of the older methods. There are dial plates at the bottom of the upright post, with indexes or hands, which, by the intervening machinery, always indicate the positions of the two arms. The whole machine is moveable on a central pivot, so as to turn round in any direction. General Pasley afterwards proposed a modification of this telegraph, as shown in Fig. 1340. The two arms are both attached to one pivot, each arm is susceptible of assuming seven different positions, and there is a subsidiary arm, *a*, to show on which side the numbers commence.

The various contrivances having a similar object in view are very numerous, and it is often curious to observe the kinds of symbols employed. It will be unnecessary, however, to pursue this subject much further. We may allude, as a last example, to Mr. Conolly's system (Fig. 1336). This consists of three square boards, with three simple devices; each board being painted with a similar device on both surfaces, but with the difference of being a black device on a white ground on one surface, and a white device on a black ground on the other. By turning the boards hinder side before, or upside down, or with one of the side edges uppermost, a great variety of different signals may be made.

Plans have at different times been devised for causing the telegraph boards or signals to be held by men, instead of being attached to machinery. It has been supposed that signals, during military and naval operations, might very conveniently be transmitted by such means. All the various kinds of boards, arms, &c., already described, might, it is very clear, be brought into use by some such means. A plan of this kind, suggested by Mr. Knight Spencer, about forty years ago, is sketched in Fig. 1337. A soldier holds in his hands two circular discs of wicker-work, about eighteen inches in diameter, with handles six inches long, and painted with a black spot in the middle of a white rim. According to the mode in which the man holds up one or both of these discs, he is enabled to express a great number of signs; six of them are shown in the cut; and it is easily to see how largely they may be multiplied. In this case, as in all the others, the signs must agree with certain preconcerted references in a dictionary or vocabulary.

Electrical Telegraph.

Nearly all the contrivances above alluded to, however ingenious they may be in their own simple department, seem likely to be superseded by the wonderful agent which has recently been brought so strongly under public notice—the *electrical telegraph.* That electricity should travel with amazing velocity has been long known; but no one was able to fix anything like a limit to this velocity, until Professor Wheatstone, by a beautiful train of experiments, showed that the electric agent—be it a fluid or an undulation—travels with a velocity equal to that of light. It is difficult to form a clear conception of this vast velocity; but it may perhaps be rendered clear, by stating that it is such as to equal the entire circumference of the globe in *one-tenth part of a second!* That such a power could travel quick enough for telegraphic purposes is sufficiently plain; but the question was, how to give a mechanical action to such a power, to render it visible or audible. Many scientific men, especially Professor Wheatstone and Mr. Cooke, have devised the means of doing this with wonderful accuracy.

The circumstance which was first made the basis of an electric telegraph was this:—When an electric current is transmitted through a wire placed parallel to a magnetic needle, either above or below it, it causes the needle to deviate either to the right or to the left, according to the direction of the current. Thus (Fig. 1338), if a magnet N S be poised on a pivot, and an electric current be passed through a wire placed parallel and beneath it, in the direction indicated by the arrows, the magnet will assume the altered position N′ S′. The magnet is thus made to turn upon a pivot, and this movement was made to act on certain index hands, which transmitted signals. This being the first germ of the method, improvements were made upon it very rapidly. The general character of the method may be seen in Fig. 1342; where *a* is the battery which generates the galvanic current; *bb* the copper wires which conduct this current, which are joined together in a coil at *c*; *d* the magnet, having an index or pointer *e*. According to which wire the currents were passed through, so would the needle be deflected to the right or to the left; and this deflection is managed by handles (Fig. 1344) in the part of the machine which contains the apparatus. There are here shown three handles, governing three magnets; and the particular angles which each magnet assumes are made to indicate certain signals: thus, as in Fig. 1345, all the letters of the alphabet may be indicated by the relative angles of four deflected magnets.

To show the mode of working an electric telegraph, in the degree of completeness which it had attained about three years ago, we will quote from the 'Companion to the British Almanac' for 1843 the following account of the telegraph used on the Blackwall Railway:—"At the Minories station is a room called the 'Telegraph room,' in which is an upright case about as large as a cabinet pianoforte. In the lower compartment of this case is a small voltaic battery (zinc, dilute acid, and copper) forming the source of motion for this end of the telegraph. Above this, the front exhibits several dials, in front of each of which one or more index-hands move. In connexion with every index-hand is a small handle, which, on being moved by an attendant, places the galvanic battery into connexion with a small magnet behind the index, by which the latter is made to deviate to the right or left. At the other end of the railway, and at the intermediate stations at Shadwell, Stepney, Limehouse, West India Docks, and Poplar, there are other telegraphs in connexion with this, wires running all along the line enclosed in a metal tube; and the arrangement is such, that whenever a particular index deviates to the right or left at the Minories station, an index deviates to the right or left at all the other stations at the same instant. If, then, a preconcerted alphabet, or key, or dictionary, or table of signals be agreed on, the relative positions of two or more index-hands will serve to convey a message. By the side of the telegraphic case a large chart is hung up, containing about a hundred sentences, instructions, or questions, each of which is symbolled by a particular position of two or three index-hands. Thus, one position, capable of being effected by two movements of the handles, implies 'Will the train wait for the next steam-boat?' Another implies, 'Will the steam-boat wait for the next train?' And others, 'How many passengers?' 'How many carriages?' and various inquiries and directions relating to the engines, the ropes, the telegraphs, and the steam-boats which start from and arrive at Blackwall. By this intercommunication, which is constantly going on throughout the day, the most minute knowledge is obtained at the London end of what is going forward at the Blackwall end, and *vice versâ*, as well as at the intermediate stations. Whenever the proper officer at each station has attached the carriages to the rope, he gives a telegraph signal thereof to the engineer at the end to which the train is going; and it is not until this engineer has thus had intimation from all the stations, that he causes his engine to act on the rope."

Many very important improvements have been made since the period just alluded to, both in producing the moving power, and in indicating signals by its means. Instead of using a magnet, Professor Wheatstone devised the means of employing a cylinder of soft iron, which becomes magnetic by the passage of a galvanic current through a coil of wire twisted round it; and in that magnetic state it attracts a small piece of iron, which is made to serve as a lever for giving motion to an index-hand. All the other parts of the apparatus have suffered repeated and thorough modifications, till the electrical telegraph has at length become one of the most exquisite examples of science applied to the arts.

Hitherto, the employment of the electric telegraph has been chiefly confined to railways. Many of the lines are "single," that is, have only one pair of rails, in order to save expense in the construction; and as a means of preventing collision by two trains coming in opposite directions on the same rails, the telegraph is adopted in many instances to give signals and directions from one station to another. Some of the double lines, also, have adopted the use of this important adjunct; and at the present time the electric telegraph is either in use, or in course of preparation, on the following lines of railway:—South Eastern, South Western, Great Western, London and Birmingham, London and Croydon, London and Blackwall, Liverpool and Manchester, Grand Junction, South Devon, Yarmouth and Norwich, North Midland, Sheffield and Manchester, Preston and Wire, Leeds and Manchester, and Edinburgh and Glasgow; while many of the projected companies also intend to adopt the use of it.

The surprising results already obtained by this wonderful apparatus in many instances must be fresh in the memory of newspaper readers; such as the playing of a game of chess by its means at the South Western Railway, the capture of a murderer through its agency on the Great Western, &c. On the occasion of the opening of the Yarmouth and Norwich line, a gentleman left the key of his carpet-bag at Norwich, and sent word by telegraph from Yarmouth, to have it forwarded to him by the next train, which was to start in a few minutes: it was done. On the Great Western line, the singular paradox occurred of a message sent in the year 1845 being received in the year 1844. Just after twelve at midnight on New Year's Eve, as shown by the clock at the Paddington station of the Great Western, a message was sent to Slough by telegraph; but, on account of the difference of longitude between the two places, midnight occurs a minute or so later at Slough than at Paddington; and as the passage of the electric mission was to all practical purposes instantaneous, the signal which was given *after* the midnight of Paddington, was received *before* the midnight of Slough.

STEAM-ENGINES AND MACHINERY.

It is frequently a source of some confusion that the term "engineering" should be applied in two different

ways—to the great constructive works connected with canals, docks, railways, &c.; and to pieces of mechanism comprised of wheels, pinions, cylinders, pistons, and other mechanical pieces of apparatus. It is true that every sound engineer, in the larger acceptation of the term, lays a foundation for his after-career by becoming closely and familiarly acquainted with the mechanical action and construction of engines, machines, and mills of various kinds; but everyday readers do not always know how to distinguish between the two when they hear mention made of an "engineer." Be this as it may, however, a few paragraphs may here fittingly be devoted to the subjects of engines and machines, so far as they seem to belong to the details of the present chapter.

Steam-Engines.

That a steam-engine is a combination of various pieces of metal, previously wrought to a definite form, is pretty well known; but the relation which these parts bear one to another cannot be distinctly appreciated without a little previous study of the phenomena of steam as a moving power. A familiar exposition of this matter, given in No. 565 of the 'Penny Magazine,' will furnish us with sufficient for the objects of the present chapter.

That ice, water, and steam, are convertible substances, every one knows, and it is also pretty generally known that heat is the agent by which the conversion from one state to another is effected. But it is not so well known that the difference of bulk between a given weight of water and of steam is the true cause of the power of the steam-engine. A cubic inch of water, weighing about two hundred and fifty-two grains, may be converted into an equal weight of steam; but in the act of transformation it increases in bulk more than seventeen hundred times, whereby a cubic inch of water becomes nearly a cubic foot of steam. How this extensive increase of bulk is brought about, we are little able to say: all which is positively known in the matter being, that a large amount of heat is taken up or absorbed during the process. A cubic inch of water at 212° may be converted into a cubic foot of steam at 212°; yet, although the thermometer indicates the same temperature in both, so large a quantity of heat has been absorbed by the steam as would suffice to raise one thousand inches of water one degree in temperature. As this large amount of absorbed heat is not perceptible by the usual test (the thermometer), it is called *latent* or "hidden" heat.

But the expansion of an inch of water into a foot of steam would be of little use to the engineer, unless there were means of effecting the subsequent reduction of the steam, and thereby producing a reaction. This reduction is effected by cold, which robs the steam of so much latent heat as to render it incapable of maintaining the vaporic form, and it thence reassumes the form of water.

These properties of steam, and many others of equal importance, were developed in successive ages, and by different philosophers; and the manner in which they may be made available as mechanical agents will, perhaps, be understood from the following notice of Newcomen's steam-engine, one of the early forms of engine:—A metallic boiler is half full of water, and is placed over a furnace or fire, the heat of which converts the water in the boiler into steam; the boiler is closed in on all sides, but it has a little aperture, covered with a valve or plug, which is opened by the force of the steam when its expansive power exceeds the pressure of the valve. A pipe conveys the steam from the boiler to an upright cylinder or barrel, in which a solid piston or plug works up and down. The top of the piston is exposed to the open air, while the bottom is wholly excluded from atmospheric action. Now the air presses on all bodies at the earth's surface with a force of about fifteen pounds per square inch, and the piston is pressed downwards in the cylinder by this force. In order, therefore, to drive the piston upwards, steam is admitted beneath it; and this steam must be raised to a high temperature—greater than 212°—in order that its expanding or elastic force may be more than a balance for that of the atmosphere. The steam, then, drives up the piston; but a question arises, how is it again to descend, so long as the steam remains beneath it? To effect this, a jet of cold water is thrown into the cylinder beneath the piston, and robs the steam of so much heat as to render it incapable of maintaining the vaporic form: it condenses into drops of water, which, occupying only one-seventeen-hundredth part of their former bulk, leave an extensive vacuum in the cylinder. The external air has now power to act unresisted, and it depresses the piston. A new admission of steam into the cylinder again forces up the piston, and a new injection of water condenses the steam, produces a partial vacuum, and causes the descent of the piston.

Now, it is easy to see what constitutes the principle of such an engine as this, and what are merely subsidiary details. The external air tends to press down the piston in the cylinder, and we have to employ an antagonist force which shall be alternately greater and smaller than this pressure. This antagonist force is steam at a temperature greater than 212°, and the same steam converted into water, thereby leaving a vacuum in the piston. The arrangement of the fire-grate and flues, so as to impart the greatest amount of heat; the shape of the boiler, and the introduction into it of a safety valve and gauge-pipes, to indicate the quantity of water and the temperature of the steam; the arrangement of the pipe and valves which admit steam from the boiler to the cylinder; the mode of injecting the water beneath the piston, and of carrying away the injected water before new steam is admitted; and the mode in which the vertical motion is, by the aid of rods, beams, levels, and wheels, made available as a mechanical agent—all these are matters of detail which call for great ingenuity on the part of the engineer, but do not touch upon the great principle of the machine.

James Watt, besides practically demonstrating many of the properties of steam indicated above, introduced a vast number of improvements into every part of the machine; and we may now briefly show how the great principle of the steam-engine has been brought into play by these improvements. The furnace and boiler are so admirably arranged, that when the fire is too strong, a damper is, by the action of the engine itself, drawn across the flues, to lower the draught; and when the water in the boiler is too low, a valve opens, and more water flows in. Steam being produced, it is carried along a pipe to the cylinder, and, in so doing, it passes through a valve so contrived as to regulate the quantity of steam admitted according to the amount of power required. The cylinder is not open at the top, as in Newcomen's engine, but is enclosed on all sides; having an internal piston wholly shielded from the external air. The downward pressure of the air is, therefore, here lost; but in lieu of it steam is admitted above the piston as well as below, though not at the same time. Newcomen's cylinder was partially cooled before each downward stroke of the piston by a jet of cold water; but Watt's cylinder must be kept constantly warm, and the condensation of the steam is effected, therefore, in a separate cylinder, kept in a cistern of cold water. Let us suppose that steam admitted above the piston presses it down; a valve is then opened, by which steam is conducted to the condenser, and instantly cooled, whereby a vacuum is formed above the piston. Meanwhile steam is being admitted below the piston, and as the latter has now a vacuum above it, it is forced upwards by the pressure from beneath. The communication between the condenser and the upper part of the cylinder is then cut off, and another opened with the lower part, whereby another series of changes occur, the steam driving the piston upwards and downwards alternately.

It has doubtless often been a matter of some perplexity, both to those who have seen a steam-engine at work and those who have not, how such a machine can do so many kinds of work—drain a mine, spin a skein of thread, stamp a coin, print a book, or make a pin's head! The explanation lies within a small compass. To the piston of every steam-engine is attached a metallic rod, which shares the reciprocatory motion given to the piston. The "stroke," or distance traversed by the piston, frequently amounts to several feet; and any machinery attached to the remote end of the piston-rod is thus moved to and fro through an equal space with great rapidity. This motion being produced, there are abundant means of giving a *circular* direction to it. Let any one witness the mode in which an itinerant knife-grinder produces a circular motion of the wheel by the vertical motion of the treadle and strap, and he will have a very distinct idea of one among the many modes of effecting such a transformation of movement. The circular motion is, in most applications of the steam-engine, first given to a large heavy "fly-wheel;" and this fly-wheel may be considered as occupying the point of connexion between the *production* and the *consumption* of steam-power. All the complex arrangements relating to the production and management of the steam have performed their wonted part when the fly-wheel is set in motion; and it is after this only a work of wheels and pinions, shafts and levers, to apply practically the power thus obtained.

The making of all the several parts of a steam-engine belongs to precisely the same class of operations as that of machinery generally, alluded to in the Chapter relating to Metals. The casting, the forging, the filing, the welding, the boring, the turning, the planing, the polishing, the boring, the drilling, the punching—these are the mechanical processes which the pieces of metal undergo, whether to make a steam-engine or any other piece of mechanism.

Some of the wood-cuts will show the complexity of various parts of the steam-engine. Fig. 1346 shows a plan and elevation of one of the kinds of piston used, so formed as to expand or contract to fit the cylinder closely. Fig. 1348 shows two different contrivances for admitting steam alternately above and below the piston in the cylinder. Fig. 1349 shows the complicated passages through which the steam passes in this alternate movement. Fig. 1351 represents a double cylinder, with intervening passages, for producing steam-power on what is termed the "expansive" principle. Fig. 1352 relates to an intricate system of steam-passages for the same purpose as 1349. Fig. 1354 represents a beautiful contrivance called a "governor," invented by Watt to regulate the quantity of steam admitted into the cylinder from the boiler. Fig. 1359 shows the "parallel motion" of Watt's engines, by which the movement of the piston is communicated to the beam. Fig. 1360 shows the internal arrangement of one of Newcomen's engines, alluded to in a former paragraph. Fig. 1361 represents the peculiar form of the plates used by some engineers for boilers, having for object the heating of the water with more than usual rapidity. In Fig. 1365 is sketched a boiler with its fire-box, in a form suited rather to a locomotive than to a stationary steam-engine.

Fire-Engines: Hydraulic Machines.

Many of the most important operations connected with engineering relate in some way or other either to the raising of water, or to the transference of water in such a way as to produce power. The common "fire-engine" is an interesting example of this kind, and one which deserves a few words of comment.

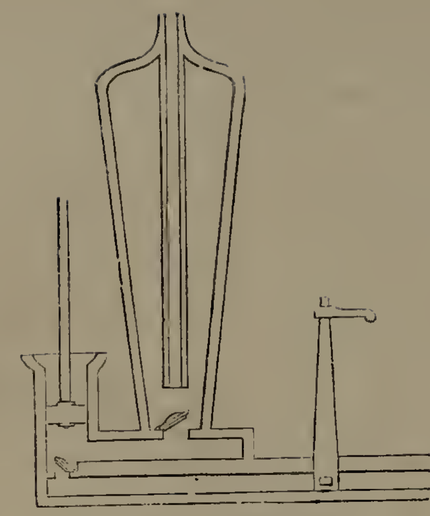
In the days when houses were more frequently built of wood than they are at present, fires were more likely to occur; but there do not appear to have been, until comparatively modern times, any regular and systematic means of extinguishing them. The first improvement, in England, upon the use of a mere bucket to throw water on a burning house, was the adoption of a kind of squirt or syringe; numbers of which were kept by the parochial authorities, in the same way as fire-engines afterwards were. Each of these squirts was about three feet in length, with an aperture at the lower end about half an inch in diameter, and a capacity of about half a gallon. It had a handle on each side, and was worked by three men, of whom two held the squirt by the handles and the nozzle, while the third worked a piston within it in the manner of a syringe: the aperture was held downwards in a vessel of water while the squirt was being filled; and when filled the nozzle was directed upwards, and the stream of water directed on the burning materials by the working of the piston.

Germany seems to have been the country where fire-engines, such as we generally understand the term, were first introduced. An inhabitant of Nüremberg, named Hautsch, constructed in 1567 a machine, consisting of a water-cistern, seven or eight feet long, drawn on a kind of sledge; it had arms or levers worked by twenty or thirty men, whose exertions propelled from the machine a stream of water an inch in diameter, and, as it is said, to a height of eighty feet. By about the year 1672, the engines had received considerable improvements, chiefly from the ingenuity of two brothers, named Vander Heyden. These persons were inspectors of apparatus for extinguishing fires at Amsterdam, and invented the flexible hose or pipes, which have ever since formed part of the fittings of a fire-engine. These flexible pipes enabled the stream of water to be carried in various directions, and thus brought to bear on parts of the burning mass which could not otherwise be reached. Fig. 1347 is copied from an old print, the inscription under which seems to show that the fire-engine here sketched (or rather one of them, for there appears to be one on a different construction in the background) was the kind first employed in Holland.

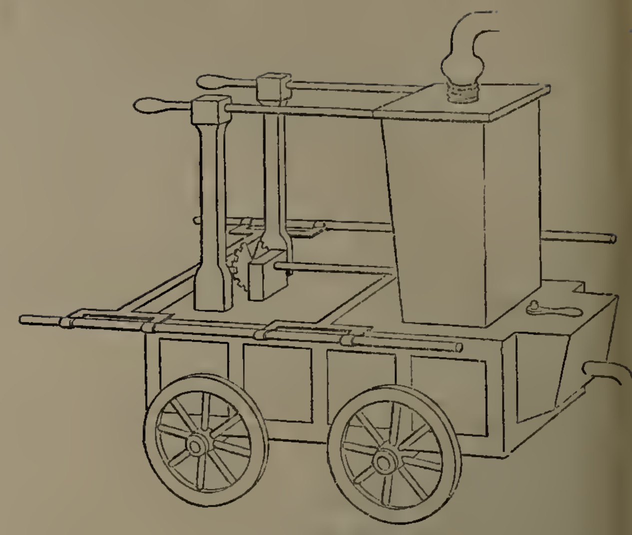
Some of these German or Dutch engines were probably brought into England, and were gradually improved upon, till they have at length reached their present effective state. In the common form of engines (Fig. 1357) there is an oblong box or cistern for containing the water, a pipe to admit it, handles to work the engine, and an upright chest or chamber, the use of which is better shown by the section in Fig. 1356. There is an upright air-chamber with various pipes and channels of communication, so planned as to cause the air confined within the upper part of the chamber to press on the water beneath it, and thus to force out the latter with more regularity than would be attained if there were no air-chamber of this kind.

Besides the fire-engines which are drawn by horses through the streets of the metropolis, there are "floating fire-engines" on the Thames, of the form shown in Fig. 1358: they require a great number of men to work them, and, when in full action, pour out an immense volume of water. Among other aids brought to bear upon this subject, an ingenious *smoke-proof dress* has been invented, which enables the firemen to make an entry into places whence they would otherwise be deterred from the fear of flame and smoke. In Fig. 1355 we have a representation of one of the London brigade firemen in the usual dress, and also one attired in the smoke-proof dress. This dress consists of a leathern jacket, and head-covering, fastened at the waist and wrists, whereby the interior is made tolerably smoke-proof; two glass windows serve for the eyes to look through; and a pipe attached to the girdle allows fresh air to be pumped into the interior of the jacket, to support the respiration of the wearer.

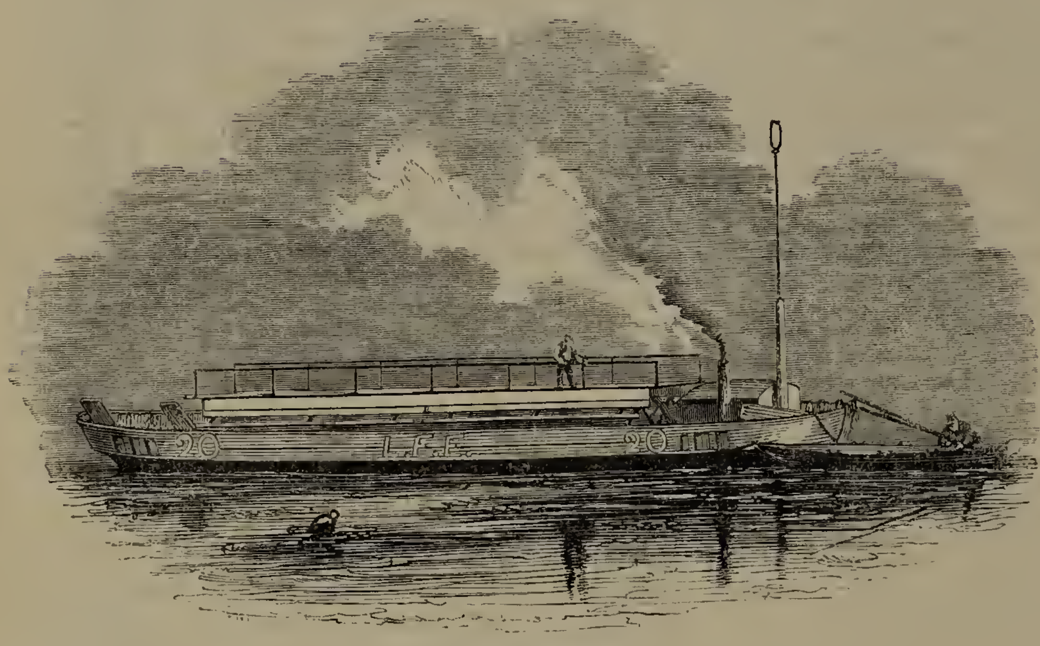
1355.—Fire-brigade Dresses.



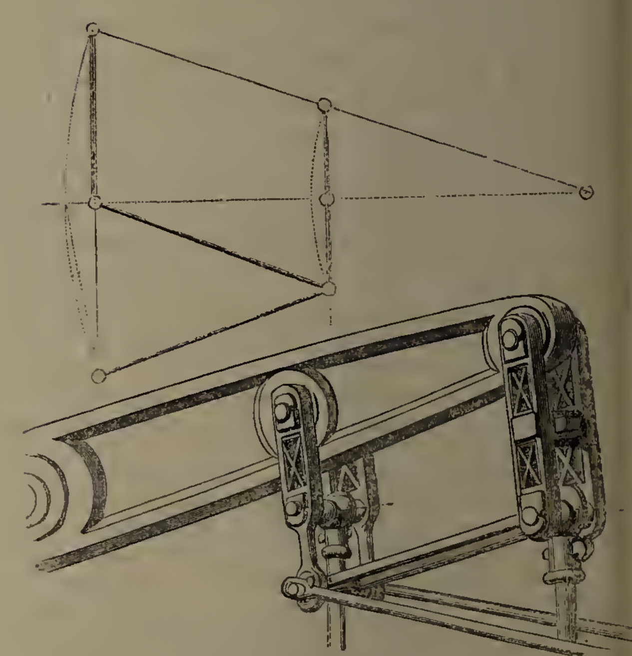
1356.—Mechanism of Fire-engine.



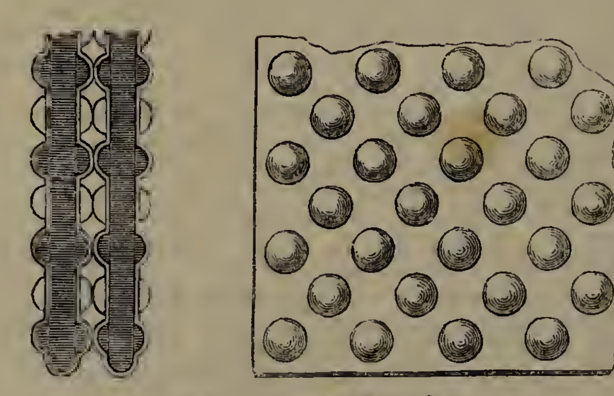
1357.—Fire-engine.



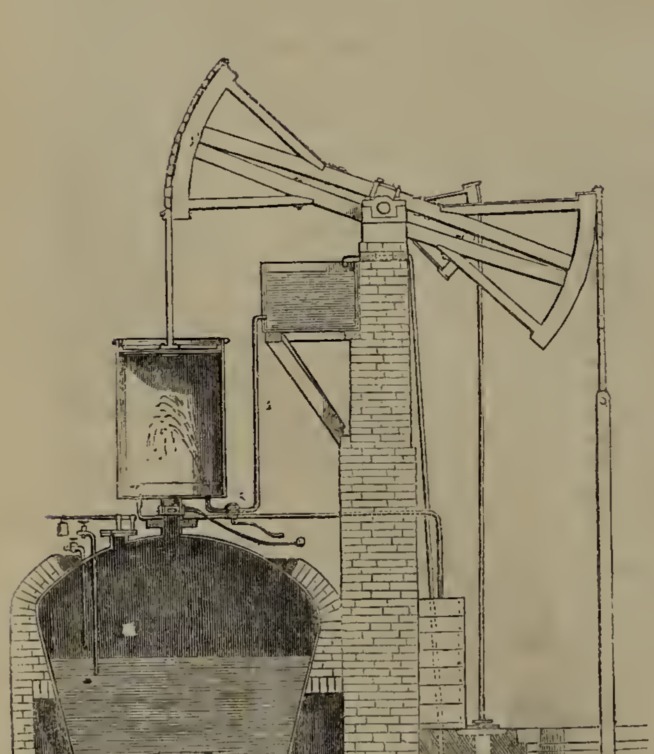
1358.—Floating Fire-engine.



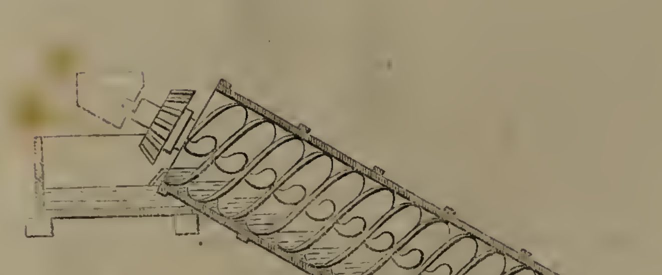
1359.—Steam-engine Apparatus.



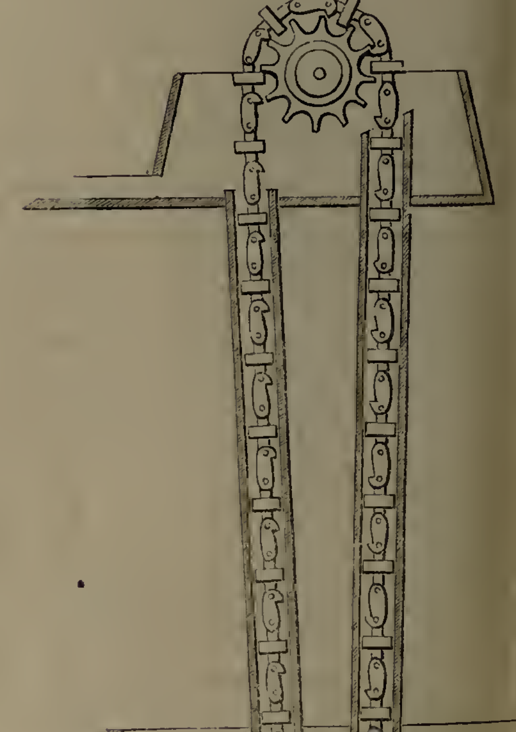
1361.—Steam-engine Boiler-plates.



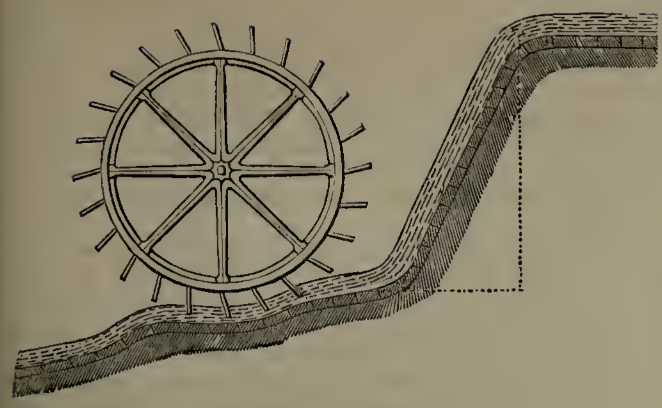
1360.—Newcomen's Steam-engine.



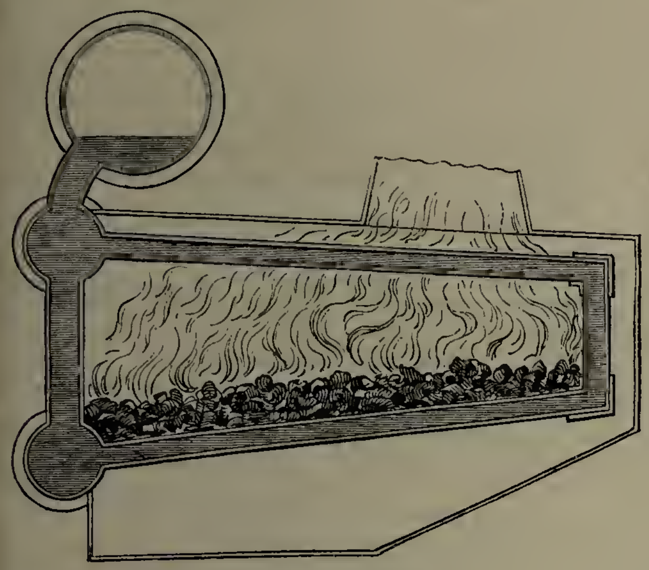
1362.—Archimedes' Screw.



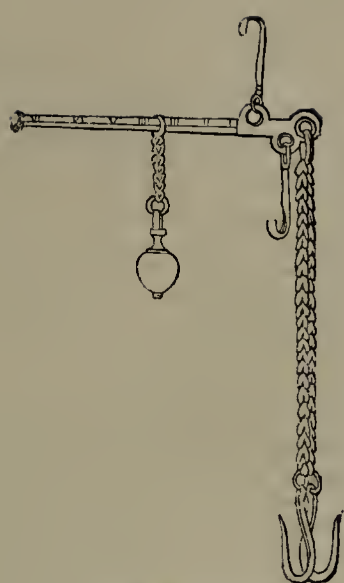
1363.—Chain Pump.



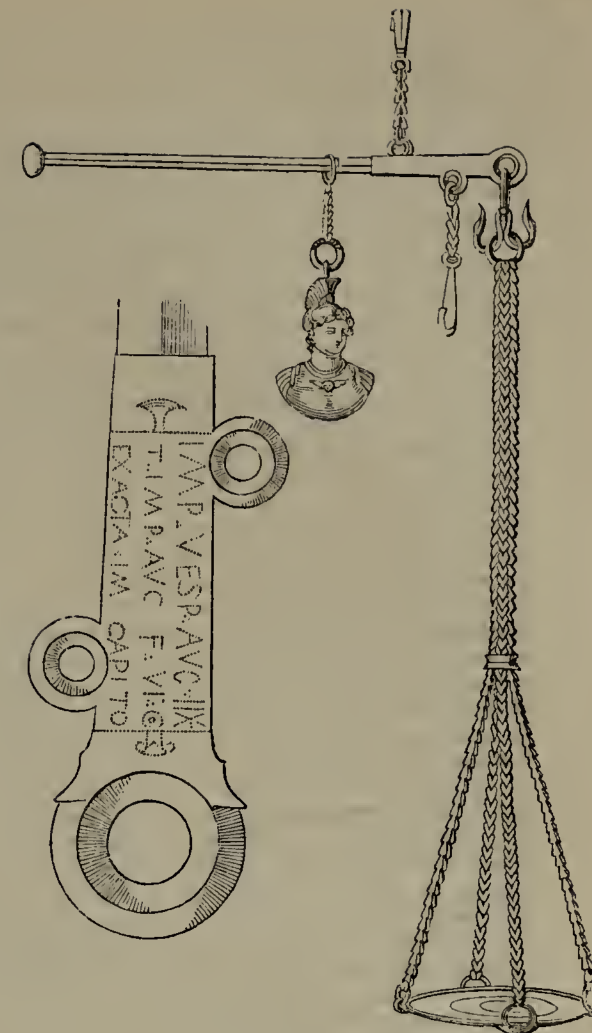
1364.—Under-shot Water-wheel.



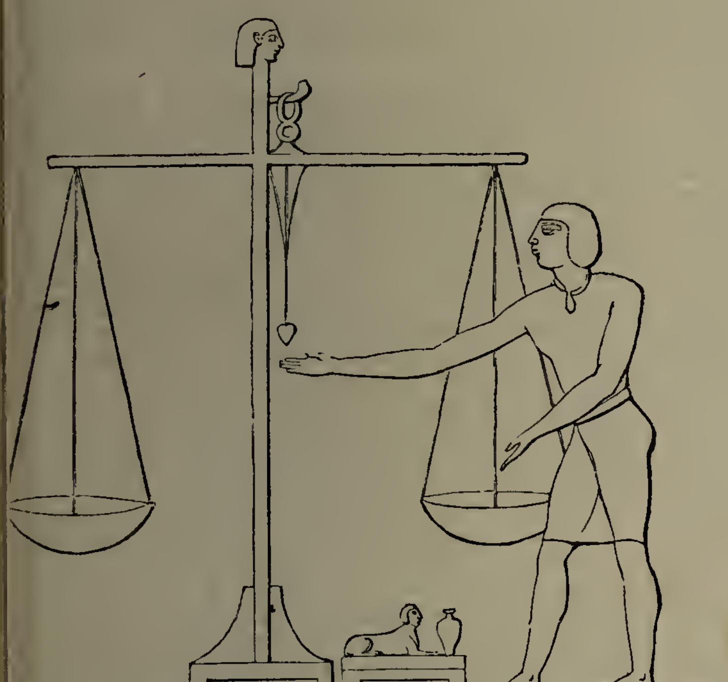
1365.—Steam-engine Fire-box.



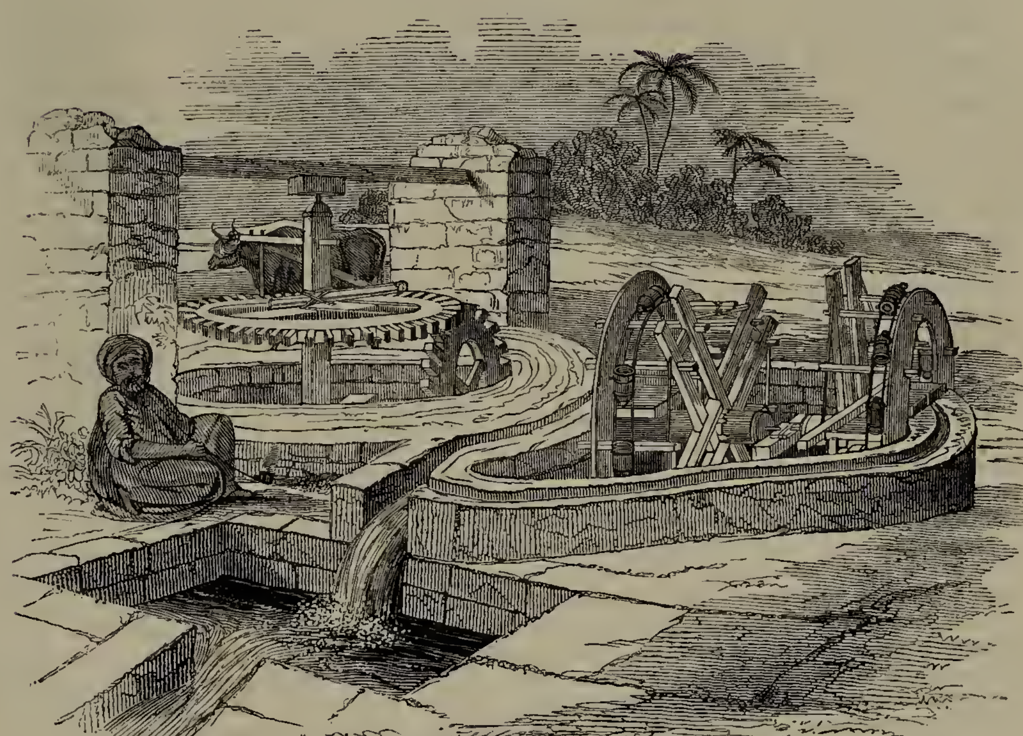
1366.—Roman Steelyard.



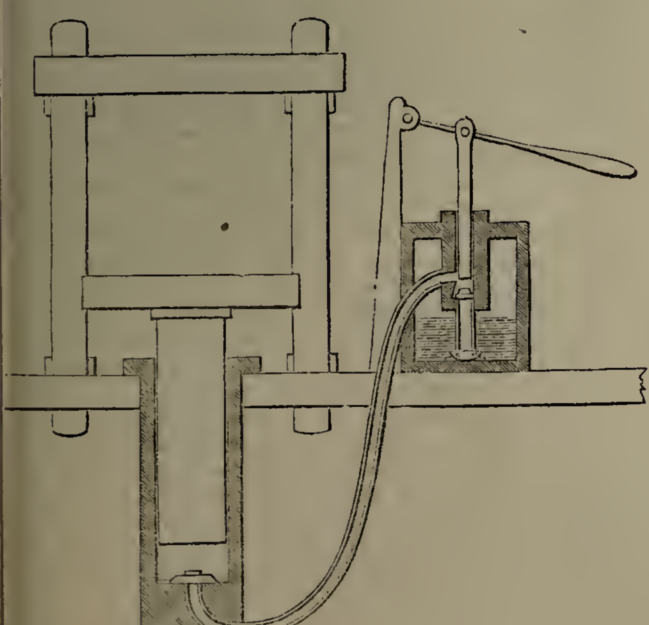
1367.—Roman Steelyard, found at Pompeii.



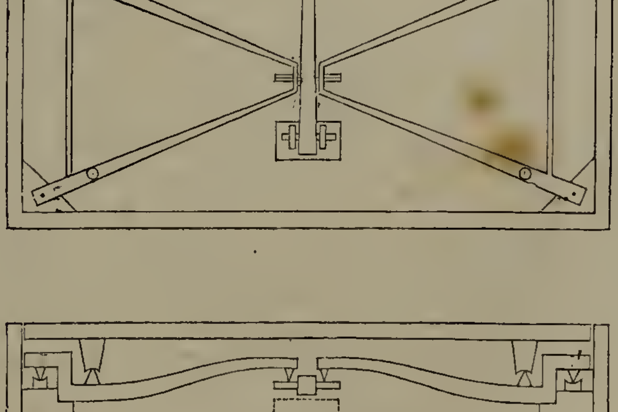
1368.—Ancient Scales. (From an Egyptian Bas-relief.)



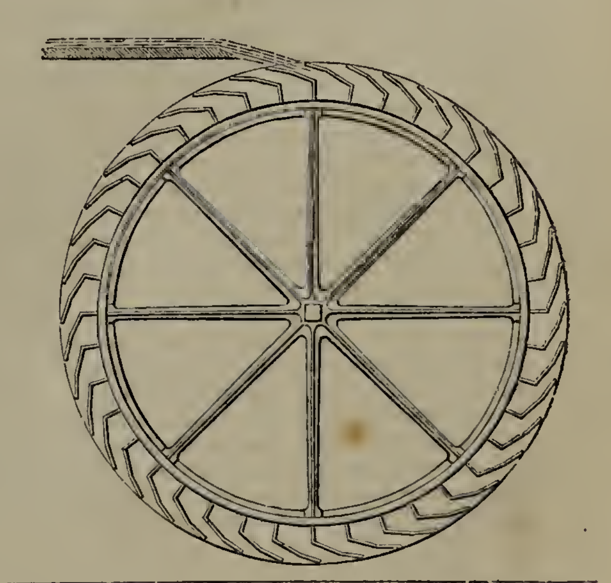
1369.—Persian Wheel; employed in Asia for raising water.



1370.—Hydraulic Press.



1371.—Weighing-machine: plan and vertical section.



1372.—Over-shot Water-wheel.

Thus equipped, the fireman is able to bear a very dense smoke without much inconvenience, though the dress is not calculated to withstand flame.

Passing on now to notice one or two other kinds of machines for raising or forcing water, it may be well to refer to Chapter II. for several details relating to the supplying of water to houses by the aid of pumps and waterworks. A few varieties not there noticed, such as chain-pumps and water-wheels, may here be glanced at.

A very curious mode of raising water, adopted, or at least suggested, by the ancients, was by means of what is termed the "Archimedean screw." This screw (Fig. 1362) is formed either of a flexible tube open at both ends and wound spirally on the exterior surface of a cylinder; or it may be a plate of metal coiled about an axis, like the threads of a screw, and enclosed within a hollow cylinder so as to be completely water-tight. The machine is fixed in an inclined position, with its lower end immersed in the water which is to be raised. While it is at rest, the water occupies the lower part between two of the threads or bends of the spiral, at the bottom; but, when turned on its axis, this part of the machine being made to ascend, the water will by its gravity be made to descend into the lower part between the next bends of the spiral, while in reality it rises with respect to its former position, in consequence of the rotation of the tubes or bends within which it is confined. The water becomes by this means worked up to the top, and is there received in any convenient vessel. Sometimes the same object is attained by the use of a pipe wound spirally about the surface of a cylinder, which is made to revolve on its axis when the latter is in a horizontal position; at one extremity of the spiral water and air in nearly equal quantities being allowed to enter, the former will, in consequence of the revolution, be forced up an ascending pipe which may be attached at the other extremity.

The *chain-pump* (Fig. 1363) is a mode of raising water sometimes adopted, when the quantity to be raised is considerable, and the depth also considerable. There is a chain, carrying a number of flat circular pistons or boards, which passes round a wheel at the upper extremity of the machine, and sometimes also at the lower: each piston, as it goes over the wheels, being in part received in the intervals between the radii. The wheel being put in motion, the pistons descend in a barrel on one side, and enter from below into another on the ascending side; and thus, pushing the water before them, they raise it into the upper reservoir. If the wheel is turned with considerable velocity, the barrel will be generally quite full of water. The lower end of the barrel dips into the water which is to be raised; and there are small holes through which this water enters the barrel.

The Persian wheel (Fig. 1369) is a convenient means, very much adopted in the East, of raising water for the purposes of irrigation. The wheel must be of greater diameter than the height to which it may be necessary to raise the water, and must stand in the stream or reservoir from which the water is to be taken. On the circumference of the wheel are a number of buckets or boxes, so hung as constantly to maintain an upright position while the wheel is revolving; and these buckets, dipping successively into the water at every revolution of the wheel, bring up water each time, and pour it out into any reservoir or channel prepared for its reception. In Asia it is customary to keep the wheel revolving by means of another toothed wheel, worked by an ox; but any other mechanical means would suffice, if more convenient.

Three or four years ago, much attention was directed to a curious contrivance, called the "Hydraulic Belt," a specimen of which was exhibited at the Polytechnic Institution. The action of this machine depends on the absorption of water by fibrous or textile materials, to such a degree as to cause the fibres to act as a channel of communication for the water. The fibres thus act as a pump; and there are two ways of attaining the object in view—by a *rope* pump and by a *belt* pump. In the former of these there is an assemblage of two, three, or more ropes, passing over pulleys fixed at the top and bottom of the space or distance through which the water is to be raised; the ropes are about an inch apart; and when the pulleys are made to revolve, the ropes (dipping into water at the bottom) carry up with them a column of water, which by a peculiar contrivance is conveyed into a reservoir at the top. It has been stated that a pump of this kind on one occasion raised nine gallons of water in a minute, from a well about a hundred feet deep, by the exertions of one man. In the belt-pump or machine, there is, instead of a pump of ropes, an endless woollen band or belt, passing over two plain rollers, one placed in the water which is to be raised, and the other at the spot where the water is to be discharged; both of the rollers revolve on their axes; and as the belt is stretched lightly over them, if one be made to revolve, the other revolves likewise: and the belt thus travels up and down alternately. When the upper roller, by being set in motion, is made to revolve with rapidity, the ascending band carries up a considerable quantity of water, which is discharged at the top by the pressure of the belt on the upper roller, and passes into any convenient receptacle.

The above examples relate chiefly to the raising of water by means of a rotating motion imparted to some kind of machine; but there is another class in which the contrary action takes place; that is, a flow of water is made to give a rotatory motion to a wheel or machine, as a source of power for manufactures. Such machines are *water-wheels*, of which there are two kinds—"undershot" and "overshot." In the "undershot" wheel (Fig. 1364) there is a stream of water conducted down a very steep channel, so that its descending power may be very considerable; and a wheel is so fixed with respect to this stream, that a number of float-boards attached to its circumference dip into the water: the moving stream, acting on these float-boards in its descent, presses violently upon them, and thereby drives the wheel round. In the "overshot" wheel (Fig. 1372) the stream is brought artificially to act upon float-boards or buckets at the upper part of the wheel instead of the lower, and thereby to put it in motion. Sometimes the water is received near the level of the axis of the wheel, in a number of buckets, which become thus heavier than those on the opposite side, and thus set the wheel in motion by their descent: these are called "balanced" wheels. Another variety again, called the "breast" wheel, differs from the last chiefly in the formation of a curved channel down which the water flows, bounding one quadrant of the wheel. In all these varieties it has been a question of much importance to engineers and practical men how to arrange the buckets or boards of the wheel so as to derive the greatest amount of advantage from their action.

Miscellaneous Machines and Engines.

Among the almost innumerable machines which help to make up the objects of the machinist's labours, is one which we have had occasion to allude to already, viz., the *hydraulic* or *Bramah press*—one of the most complete and valuable modes yet known of producing an intense pressure by very easy means. One of these is shown in a former chapter (Fig. 538) in connexion with Bandana-work; another will be sketched in the next chapter, in connexion with printing; and a third is given in Fig. 1370, to illustrate the internal arrangements of such machines. This kind of press, which was invented by the highly ingenious machinist Mr. Bramah, is to some extent an hydraulic machine, since it owes its peculiar power to the incompressibility of water. Near the lower part of the machine is a vertical iron cylinder, in which a piston works. At the bottom of the cylinder is inserted a tube, whose aperture under the piston is covered by a valve. The other end of the tube communicates with a small forcing-pump, by which water is driven through the valve into the lower part of the cylinder, where its hydrostatic action is exerted to raise up the piston. If water were elastic or yielding in the same manner as air, even to a much smaller degree, it would be condensed in the space between the valve and the piston, and the latter would not be raised with any considerable force; but water is so very nearly incompressible, that it will resist almost any force rather than suffer contraction into a smaller bulk. The amount of the force thus resisted depends mainly on the relative diameters of the piston in the forcing-pump and the piston in the cylinder—the latter being always very much greater than the former.

A delicate and curious kind of mechanism, calling for the aid of the man of science as well as the mere mechanician, is that relating to the process of weighing, whether by the scales, by the steelyard, or by a larger weighing-machine. Figs. 1359, 1366, 1367, 1368, 1371, illustrate some of these. The steelyard is a lever, having the article to be weighed at one end, and a balance weight on the other side of the fulcrum. This weight is not, as in the case of the common scales, changed when any difference occurs in the weight of the article put at the other end of the lever, but the counterpoise slides along the longer arm of the lever, in such a manner that its effect as a counterbalance increases in power as it is placed farther and farther from the fulcrum. In the common form of the instrument, a hook is usually suspended from the short arm, to hold the article which is to be weighed; but sometimes a scale-dish is suspended by a chain for this purpose. The moveable weight is commonly attached to a ring, the form of which enables it to rest in notches cut on the upper edge of the steelyard, corresponding with a row of graduated marks engraved on its side. Many steelyards are supplied with an additional fulcrum; the two being placed at different distances from the point to which the hook or scale is attached, and having their respective suspending hooks on opposite sides of the lever, or one above and the other below it. Some steelyards have been made with such delicate and accurate adjustments, for scientific purposes, that they have been able to indicate so small a quantity as one ten-thousandth part of the weight with which they were loaded.

Various instruments are used, somewhat midway between the common steelyard and the common balance or scales. Thus the Danish balance, used in commercial matters in the countries near the Baltic, differs from the steelyard in this circumstance—that the counterpoise is fixed and the pivot moveable, whereas in the steelyard the pivot is fixed, and the counterpoise moveable. The beam is graduated in a contrary direction to that of the steelyard, in order to adapt it to this change; and the beam has to be slid forwards or backwards according to the weight to be counterpoised. There are machines called "bent-lever" balances, in which the weight is suspended from a bent arm, and counterpoised by a heavy knob at the other end of the arm; and the degree to which the heavy knob ascends is made to indicate the weight of the article attached to the bent arm. A considerable number of machines having similar objects in view, depend upon the recoil and resistance of a spring, instead of upon the movement of a lever.

The common balance, or "pair of scales," depends for its action on the horizontal position assumed by the two arms of a lever, when they are of equal length from the pivot or fulcrum, and loaded with equal weights at the extreme ends. This double lever constitutes the *beam* of the balance; and when the beam is perfectly horizontal, the mechanism of the whole should be so delicate as to make the balance turn with an extremely small weight at either end. This sensibility depends chiefly on the absence of friction at the pivot; and to make this friction as slight as possible the beam is placed on its support through the intervention of knife edges. So extraordinary is the degree of delicacy sometimes produced in these instruments, when made for scientific purposes, that a balance made by Ramsden for the Royal Society, weighing ten pounds altogether, turned with the ten-millionth of that quantity, or with about the thousandth part of a grain! Such very delicate instruments are made with a sedulous attention to all the circumstances which may disturb them.

The *weighing-machines* often employed for determining the weight of loaded waggons, or other ponderous articles, are among the largest machines to which the name of the balance could with propriety be applied. One of them is sketched in Fig. 1371; the upper portion being a plan, and the lower a vertical section of the machine. Such a machine is a platform sunk on a level with the roadway, and made to rest at four points on a double lever; the extremities of the arms of these levers rest upon a third lever, and this latter may be made to indicate in various different ways the amount of weight resting on the platform. There is in the first place a rectangular pit sunk in the ground, eight or ten feet long by six feet broad, and about two deep: the sides and bottom of this pit are lined with brickwork or iron. In this pit is built up the assemblage of levers and pivots seen in the cut, the mutual action of which is such as give a slight movement to the long bar projecting from one side, whenever there is a heavy weight on the platform. This long bar communicates with some kind of steelyard or spring balance, which is consulted when it is desired to know what amount of weight is on the platform. The platform is seen edgewise in the section; but it is not represented in the horizontal plan, where it is omitted for the sake of showing the system of levers beneath it.

Such, then, are a few of the most striking examples of the kinds and diversities of art applied to the purposes of Civil Engineering. It is abundantly evident that the man who is capable of planning and superintending a large engineering project must have his mind imbued with a vast amount of knowledge on almost every branch of mechanical science. The qualities of materials, the principles which regulate equilibrium and pressure, the action of machines—all must come under his notice. Besides the almost innumerable *practical* details which call for his constant attention, he must be familiar with much that is purely scientific: indeed, it has been observed that "the course of education by which a student may qualify himself to become an engineer, whether civil or military, must necessarily comprehend a greater extent both of the pure and physical sciences than could be required from a person who is to follow any other profession." How this knowledge has been in many instances attained, and through what difficulties the student has had to struggle in the attainment, the lives of many of our engineers would strikingly exemplify.

CHAPTER X.

THE ARTS CONTRIBUTORY TO WRITING, BOOKS, AND MUSIC.

It would not be an unapt expression to say that the main object of the present chapter is to consider the *mechanical aids to education*, or the relation which Industrial Art bears to Mental Culture. Nearly all the matters which come daily under our notice might, by a judicious use of them, be made to contribute something to the general stock of knowledge and mental improvement; but the means of expressing Thought in Writing, and of facilitating the transference of this Thought from one to another by means of Printing, are (so far as regards *mechanical* aid) so much more important than any other bearing on this subject, that it will suffice to make these the chief object of the present chapter. The remainder will afford us a convenient opportunity for saying a little concerning Music, in relation—not to the principles on which it is founded, or the rules for its practical study—but to the mechanism of the instruments themselves.

THE MATERIALS AND IMPLEMENTS OF WRITING.

It is easy to see that the materials and implements for writing, however diversified they may appear, belong to one or other of four classes—the plain, smooth surface on which the letters are written; the instrument for shaping the letters; the liquid or colouring substances for making these shaped letters visible; and the means for securing the writing when finished. Most of these will come successively under notice.

Writing Materials of the Ancients and the Orientals.

The remains at Pompeii and Herculaneum—rich in almost all kinds of specimens—are not deficient in examples of the kinds of writing materials used by the Romans. From these it appears that the manuscripts were written either on parchment and vellum, or upon a vegetable tissue made from a rush called *papyrus.* This papyrus has a stalk consisting of a number of thin concentric coats; these coats the ancients were accustomed to detach carefully, and to paste them crosswise one over another, like the warp and weft in textile goods, so that the fibres ran at right angles to ensure strength: the surface was then polished with a shell, or some hard smooth substance. The ink employed was a simple black liquid, containing no mordant to give it durability, so that the writing was easily rubbed out by means of a sponge. The papyri, or prepared sheets, used by the Greeks varied from eight to twelve inches in length, but those employed by the Romans sometimes reached the length of sixteen inches. The writing was in columns, placed at right angles to the length of the roll.

The five small cuts (Figs. 1374 to 1376, 1380 and 1381) represent many of the books and writing materials used by the Romans. In Fig. 1375, at the left hand side, are represented two papyri rolls or books, one closed and the other partially open. The other side of the same cut shows an open book, consisting of two tablets or pages, which served for memoranda and other temporary writings—much in the same way as a slate would be at the present day. These books were composed of leaves of wood or metal coated over with wax, upon which the writing was made with a "stylus," or style, which was a solid sharp-pointed instrument, several inches in length. In the middle of each leaf there was a kind of button, intended to prevent the pages from touching when the book was closed. In Fig. 1380 we see, at the left hand side, a tablet-book consisting of several leaves, instead of only two, as in the former instance. There stands by the side of this tablet a double inkstand, intended, probably, for ink of two colours. The ancients had red ink, prepared chiefly from cinnabar; while the black ink was prepared from charcoal, from lamp-black, or from the cuttle-fish; and, instead of leaving permanent writing on the tablets, both the ink and the tablets themselves seem to have been made with a view to the easy obliteration of the writing. Near the inkstand is a "calamus," or pointed reed for writing with ink; and by the side of this is a papyrus opened, to show how a manuscript was read: it being rolled up at each end, so as to exhibit at one time only as much writing as is contained in one column.

In Fig. 1381 we see a set of tablets similar to those before described, and also one which seems to be hanging up against the wall. The cut also contains a papyrus roll, an inkstand, and two styles, or pens. The styles were made of various materials, sometimes of the precious metals, but more frequently of iron. In another cut (Fig. 1374), besides a double inkstand, there is an open book made of leaves of parchment or vellum, tied together with ribbon. The manuscript papyri or rolls were contained in some such a box as that seen in the centre of Fig. 1376; the box was a cylinder, in which the manuscripts were placed vertically, and it was thus possible to arrange a large number of written documents in a box of comparatively small size. Near the box is a tablet, on which (from the coins strewed about) accounts and reckonings had probably been written.

In all civilized countries at former times, and in Oriental countries at the present day, the writing materials have been pretty much of the same general character. Thus, the books made by the inhabitants of Ceylon (Fig. 1391) consist of strips of the leaves of the talipot-tree: these leaves are not sewed, but are kept together by two strings, which pass through two holes made in each of them, and are fastened to the upper covering of the book by two knobs. The outside or cover of the book is made of two boards of hard wood, often beautifully ornamented and painted.

Dr. Kitto, in his notes to the 'Pictorial Bible,' speaks of the ancient Jewish books as having been of several different kinds. Tablets of wood, written on with some sort of ink, was one sort employed; and the leaves of the tablet-books were connected together by rings at the back, through which was passed a rod to serve as a handle for carrying them. The fine inner bark of such trees as the lime, the ash, the maple, and the elm was much used for this purpose; and all such written pages were rolled up round a cylinder or stick, sometimes at one end, and sometimes at both: hence the term "volumen" (a thing rolled up), although we apply the analogous word "volume" to a flat book in which there is no rolling up at all. The leaves of trees were often employed, and have been so since in many countries, especially the leaves of the palm, the palmyra, and the talipot. On such sort of manuscripts the letters were written with a sharp-pointed style, and a mixture of oil and charcoal was rubbed into the marks to render them visible. The Jews wrote sometimes with a kind of paint, rather than ink, on linen prepared by a peculiar substance. Tablets of lead, copper, brass, and other metals were also employed when the writing was intended to be permanent; for in such cases the words were not merely written, they were engraved on the metal itself. Montfaucon purchased at Rome, in 1699, an ancient book composed entirely of lead: it was about four inches long by three inches wide; and not only were the two pieces that formed the cover and the leaves (six in number) of lead, but also the stick inserted through the rings to hold the leaves together, as well as the hinges and nails. It contained some unintelligible Egyptian writing and figures. The figure of a female reading a manuscript, copied from an ancient picture, in Fig. 1377, and the various sorts of books and manuscripts depicted in Fig. 1378, will illustrate many of the above details.

With respect to the ink, inkstands, and pens in use in Oriental countries, Dr. Kitto remarks that the scribes usually carry about with them "a flat case, about nine inches long by an inch and a quarter broad, and half an inch thick, the bottom of which serves to contain the reed-pens and penknife. It is furnished at one end with a lid attached by a hinge. To the flat side of this shaft, at the end furnished with the lid, is soldered the ink-vessel, which has at the top a lid with a hinge and clasp, fitting very closely (Fig. 1393). The ink-vessel is usually twice as heavy as the shaft: the latter is passed through the girdle, and is prevented from slipping through by the projecting ink-vessel. The whole is usually of polished metal, brass, copper, or silver. The case for pens and ink is worn in the same manner by the Persians, but it is very different in its form and appearance. It is a long case, eight or nine inches long by about one and a half broad, and rather less in depth, rounded at each end. It is made of paper stiff as board, and the whole exterior is japanned, and covered with richly-coloured drawings. This case contains another, which fits it exactly, and may be considered as a long drawer: it is of course uncovered at top, and slips into the outer case at one end, so that it can be easily drawn out, wholly or partially, to give access to the contents." These implements are sketched in Fig. 1383. At the top are the several parts of the writing-case, closed and open; beneath is a little spoon, for diluting the ink with water; a reed-pen is beneath this, together with a piece of horn and a piece of whetstone, for nibbing and sharpening the pen. The inkstand is shown at the right hand corner, and near it is a small magnetic needle under a glass, to enable the owner to find the direction of Mecca when he prays, in accordance with the usages of the Mohammedans.

The ink employed by these Eastern nations is said, by the same authority, to be "usually composed of lamp-black, or powdered charcoal prepared with gum and water, and sold in small particles or grains like gunpowder. The writer who wants to replenish his inkhorn puts some of this into it, and adds a little water, but not enough to render the ink thinner than our printers'. Those who use much of it work up the ink-grain with water, much in the same way that artists prepare their colours, and then put it into their inkstands. In the manuscripts written with this ink the characters appear of a most intense and glossy black, which never changes its hue, never eats into the paper, nor ever becomes indistinct or obliterated except from the action of water, by which it is even more easily spoiled than our own manuscripts. The Eastern scribes also write in gold, and with inks of various brilliant colours, particularly red and blue—their diversified applications of which often give a very rich and beautiful appearance to the page in the higher class of manuscripts."

Mr. Lane gives a representation of the various writing materials used by the modern Egyptians (Fig. 1373), and a description of most of them. He says that the leaves of the books are seldom sewn together, but that they are grouped into small pieces of five each, in order that several persons may read the book at once, each one being a "karra's," or group of five leaves. The name of the book is often written on the edge of the leaves. The Egyptians have left off using papyrus, and now employ thick glazed paper brought from Venice. The ink used is very thick and gummy. The writer places the paper on his knee, or on the palm of his hand, or on a sort of pad formed of several thicknesses of paper, and writes with a pen made of reed, which is said to be better fitted for the Arabic characters than one made of quill. The paper is ruled before being written on.

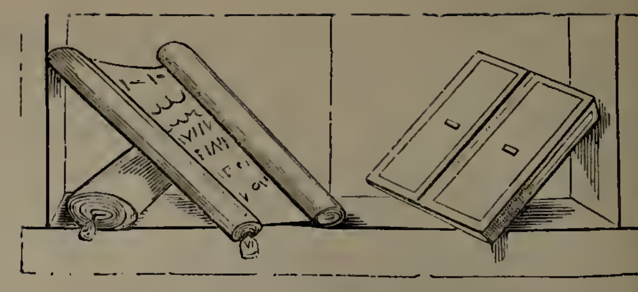
Records, Rolls, and Parchment Manuscripts.

When we come down to a period more nearly approaching our own era, and countries nearer to England, we find that *parchment* became extensively and generally adopted as a material for writing.

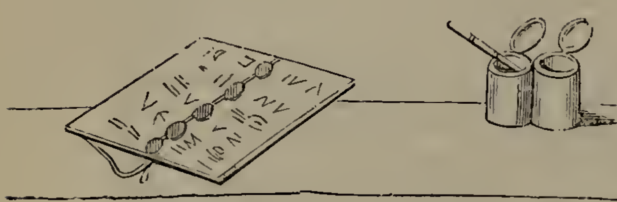
Parchment and vellum belong to a class of substances which were partially used by the ancients for these purposes, viz., skins of animals. Allusions are found in some of the classical writers to inscriptions written on the skins of goats and sheep: it has, indeed, been supposed that the Books of Moses were written on such skins. Dr. Buchanan some years ago discovered, in the record chest of some Jews at Malabar, a manuscript copy of the greater part of the Pentateuch, written in Hebrew on goats' skins. The goat-skins were thirty-seven in number, dyed red, and were sewn together, so as to form a roll forty-eight feet in length by twenty-two inches in width. At what date this was written cannot be now determined, but it is supposed to be extremely ancient. Parch-

1373.—Modern Egyptian Writing-Implements.

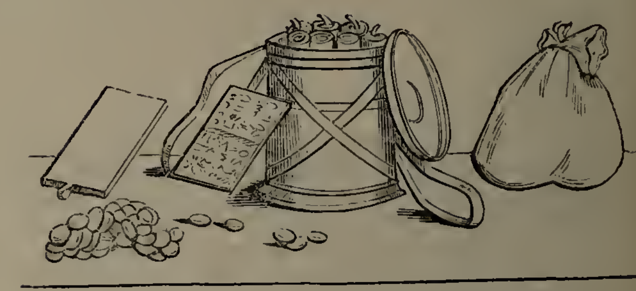
1377.—Ancient Papyrus Book or Roll.



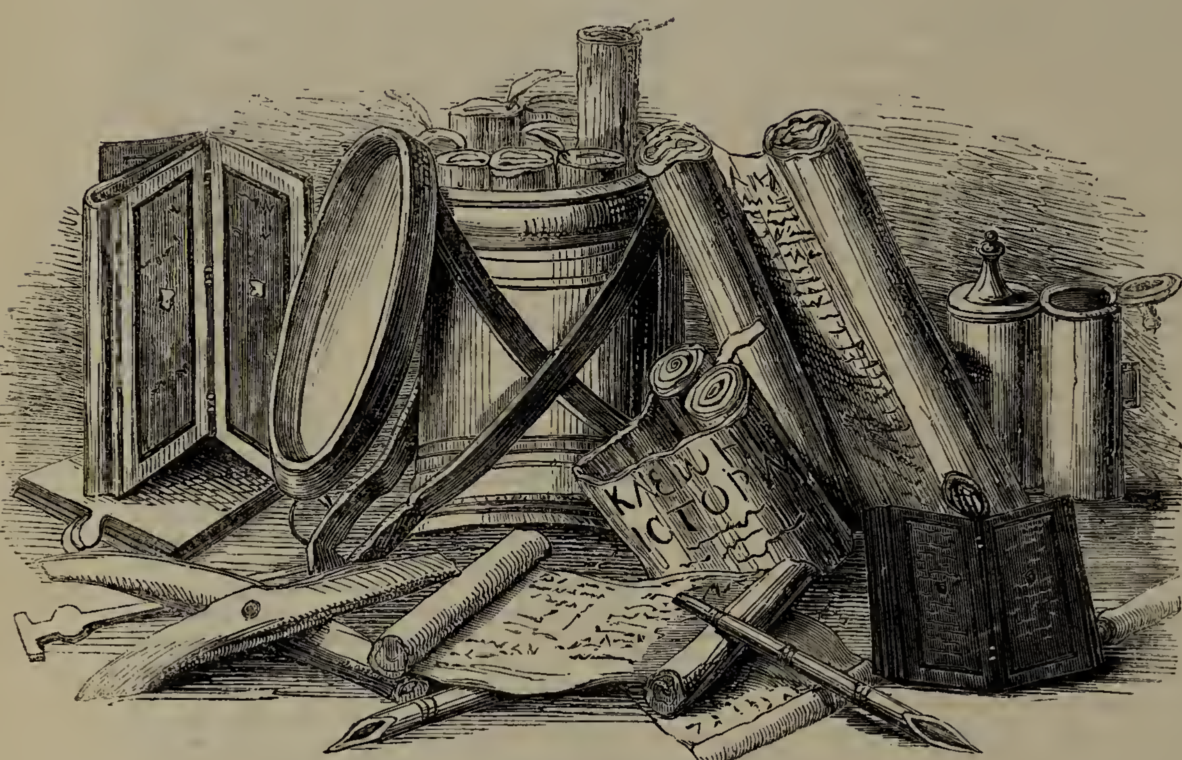
1375.—Ancient forms of Books. (From Pompeii.)



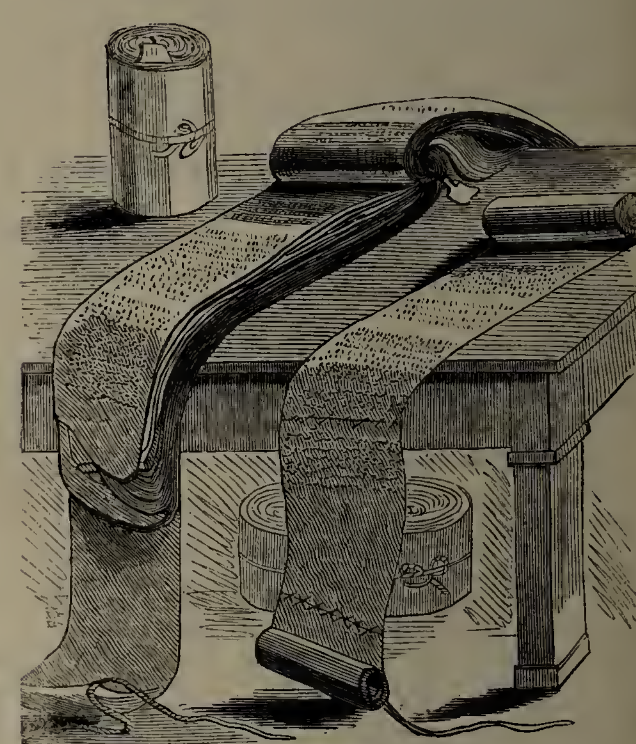
1374.—Tablet and Inkstands. (From Pompeii.)



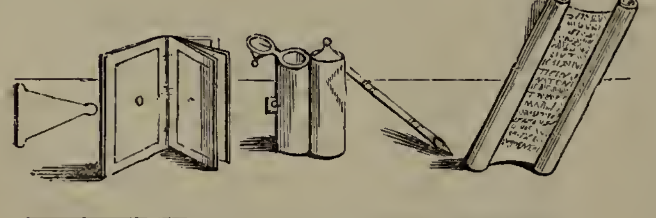
1376.—Manuscript-box and Tablets. (From Pompeii.)



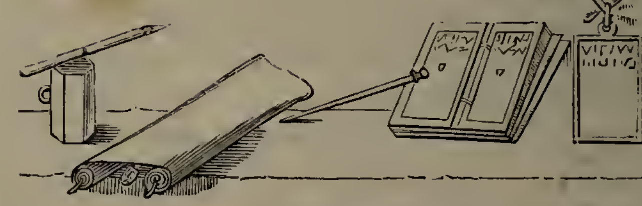
1378.—Ancient Writing Materials and Implements.



1379.—Old English Records, or Manuscripts on Parchment.

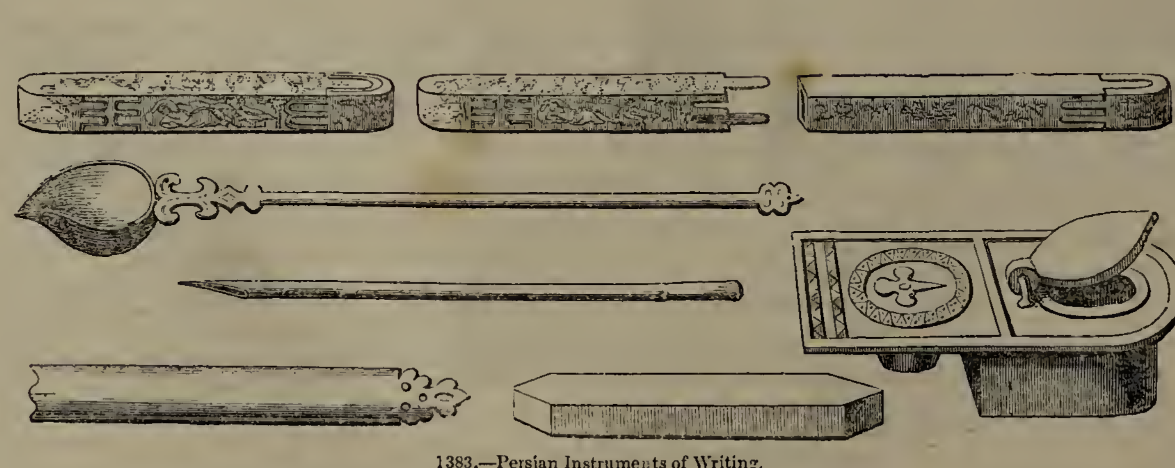


1380.—Tablets, Papyrus, and Inkstand. (From Pompeii.)



1381.—Tablets, Papyrus, and Inkstand. (From Pompeii.)

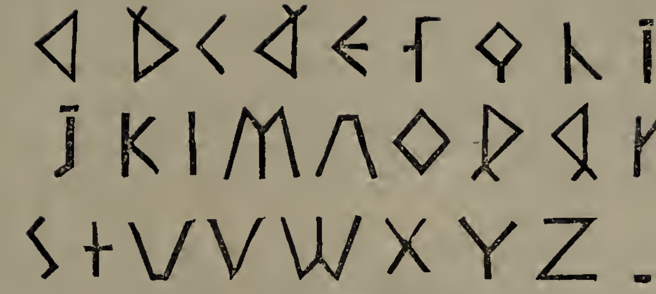
1382.—Transcriber at work.
(From an Egyptian Painting.)



1383.—Persian Instruments of Writing.

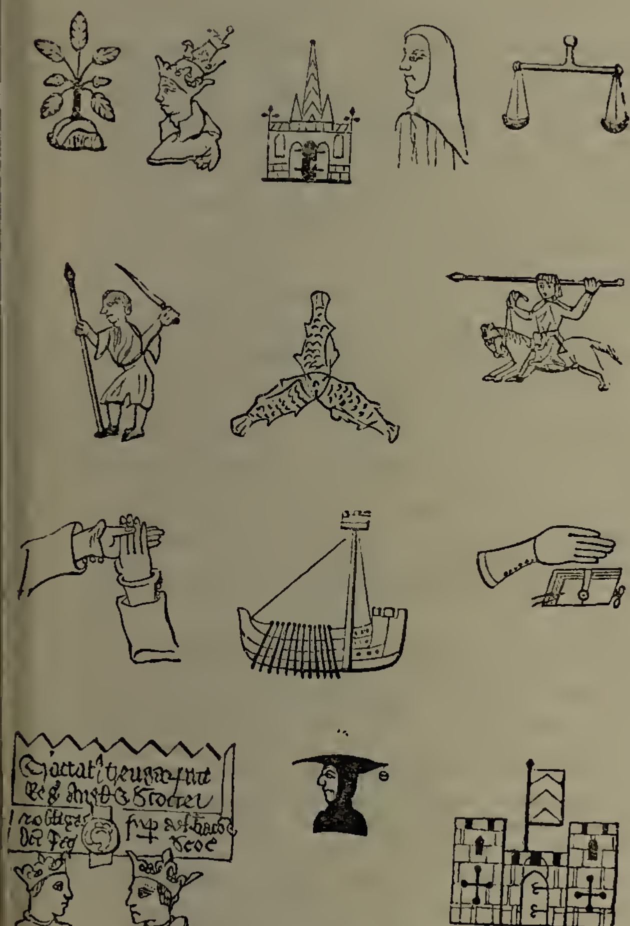
1384.—Transcriber at work.
(From an Illuminated MS.)

1385.—"Hanaper," for Old Records.



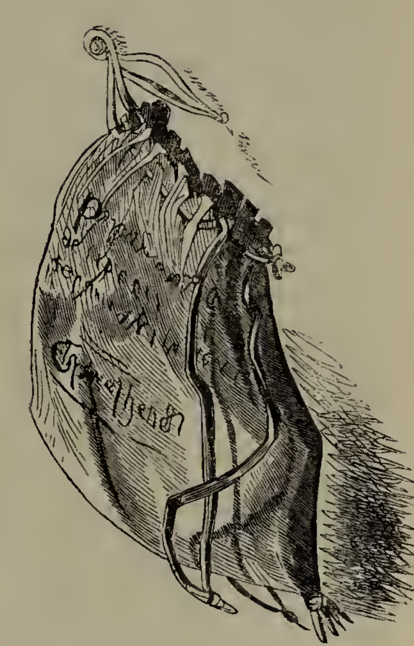
1386.—Gall's Alphabet for the Blind.

1387.—"Skippet," for Old Records.

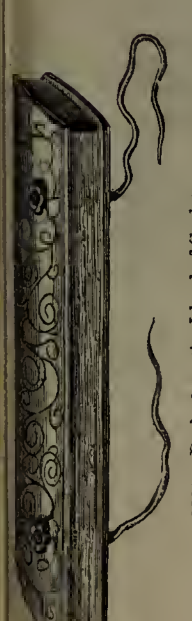


1388.—Signs or Symbols on Old Records.

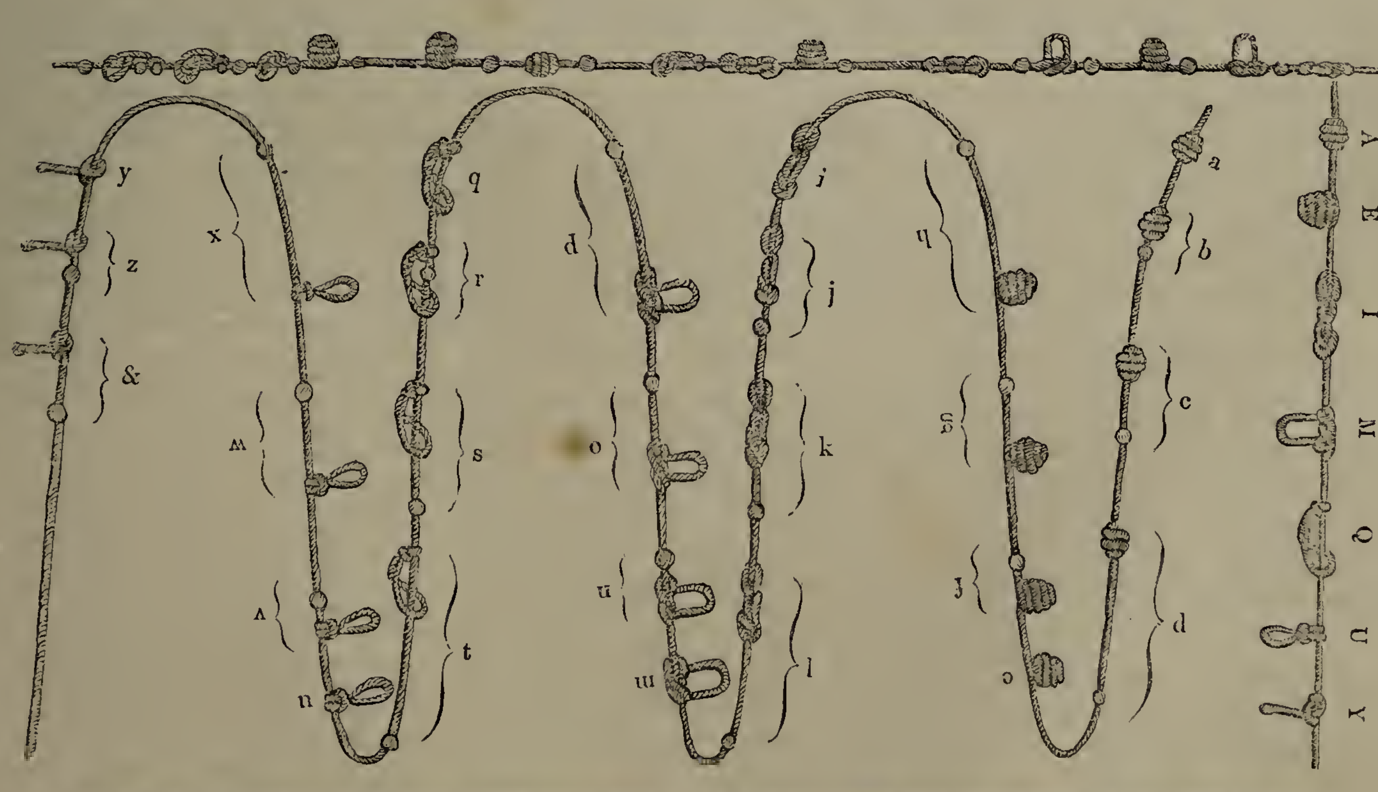
1389.—German Itinerant Mapseller.



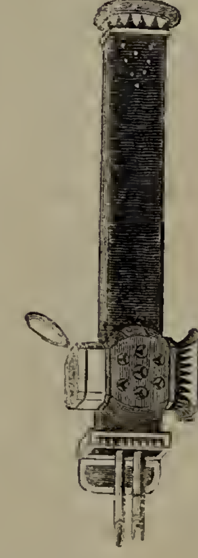
1390.—Leathern Pouch, for Old Records.



1391.—Book, from the Island of Ceylon.



1392.—String-Alphabet, for the Blind.



1393.—Modern Oriental Writing-case and Instruments.

ment, considered as a prepared variety of skin, is of much later introduction, and is said to have been first prepared in the time of Ptolemy Philadelphus. This material came by degrees to be employed for legal, sacred, and other particular classes of works; but the comparative cheapness of papyrus, combined with as much durability as could be required for the more common literary works, maintained it still in general use. The Jews began, early after the invention of parchment, to write their scriptures on this material, of which the rolls of the law used in their synagogues are still composed.

A curious kind of document, which linked the classical times with the middle ages, in respect to the use of parchment, was afforded by the "palimpsests," or manuscripts from which old writing had been erased in order to make way for new. A well-prepared leaf of parchment was so costly an article in the middle ages, that the transcribers who were employed by the monastic establishments in writing often availed themselves of some old manuscript, from which they scraped off the writing: such a doubly-used piece of parchment was called a "palimpsest." This practice seems to have been followed long before, but not to so great an extent as about the fourteenth and fifteenth centuries, at which time there were persons regularly employed as "parchment-restorers." The transcribers had a peculiar kind of knife, with which they scratched out the old writing; and they rubbed the surface with powdered pumice-stone, to prepare it for receiving the new ink. So common was this practice that, when one of the emperors of Germany established the office of imperial notary, it was one of the articles or conditions attached to the holding of the office that the notary should not use "scraped vellum" in drawing deeds. Sometimes the original writing, by a careful treatment of the parchment, has been so far restored as to be visible, and it is found to be parallel, diagonal, and sometimes at right angles to the writing afterwards introduced. In many cases the ancient writing restored beneath is found to be infinitely more valuable than the monkish legends written afterwards.

The rolls and records connected with the early parliamentary and legal proceedings in England furnish interesting examples of the use of parchment in writing. The "Records," so often alluded to in such matters, are statements or details, written upon rolls of parchment, of the proceedings in those higher courts of law which are distinguished as "Courts of Record." It has been stated that "Our stores of public records are justly reckoned to excell in age, beauty, correctness, and authority, whatever the choicest archives abroad can boast of the like sort." During the present century a great deal of attention has been bestowed upon this subject, by parliament, by the courts of law, and by private societies and individuals, with a view to the preservation of documents which are felt to be of great historical value.

The records are generally made of several skins or sheets of parchment or vellum, each sheet being about three feet long and often nine to fourteen inches in width. They are either all fastened together at one end, so as to form a kind of book, or are stitched end to end, so as to constitute an extended roll: both of these forms are shown in Fig. 1379. These two methods appear each to have had its particular advantages, according to the way in which and the time at which the manuscript was filled up. Some of the records of the former of these two kinds contain so many skins of parchment that they form a huge roll equal in size to a large Cheshire cheese, and requiring the strength of two men to lift them.. Some of those on the continuous plan are also said to be of immense size: one, of modern date, is nine hundred feet in length, and employs a man three hours to unrol it. The invaluable old record, known by the name of "Domesday Book," is shaped like a book, and is much more convenient to open than most of the others. Various other legal documents, to an immense amount, are "filed," or fastened together by a string passing through them.

It seems a very strange contradiction, but it is positively asserted as a fact, that the parchment employed for these records was of very fine quality down to the time of Elizabeth, but that it gradually deteriorated afterwards, insomuch that the latest are the worst: this must be due either to parsimony or to mismanagement, for it can hardly be supposed that the parchment-makers of our day could not equal those of past ages. Not only the parchment, but the ink and the handwriting are said to be worse in our day than centuries ago. Some of the records and rolls are written in Latin, some in Norman French, and some in English.

The modes of depositing and carrying the ancient records were curious. There seems to have been no very definite arrangement in this respect. Great numbers were kept in pouches or bags made of leather, canvas, cordovan, or buckram (Fig. 1390): they were tied like modern reticules. When such pouches have escaped damp, they have preserved the parchment records for centuries perfectly clean and uninjured. Another kind of receptacle for the records was a small turned box, called a "skippet" (Fig. 1387); and another was the "hanaper," or "hamper" (Fig. 1385), a basket made of twigs or wicker-work. Chests, coffers, and cases of various shapes and sizes, formed other receptacles for the records. The mode of finding the particular document required was not by a system of paging and an index, as in a modern book, because the arrangement of the written sheets did not admit of this; but there were letters, signs, and inscriptions or labels for this purpose. In Fig. 1388 many of these are represented: they constitute an odd assemblage, comprising ships, scales, balances, castles, plants, animals, &c.; in most instances the signs or symbols bear some analogy, or supposed analogy, with the subject of the record;—such as an oak on a record relating to the forest laws; a head in a cowl on one relating to a monastery; scales on one relating to coining, &c.

At a time when books were prepared by hand instead of by printing, and when each copy became very valuable, books were treated with a degree of respect which can be hardly understood at the present day. The clergy and the monks were almost exclusively the readers of those days; and they held the other classes of society in so much contempt, in all that regarded literature and learning, that Bishop de Burg, who wrote about five centuries ago, expresses an opinion that "Laymen, to whom it matters not whether they look at a book turned wrong side upwards or spread before them in natural order, are altogether unworthy of any communion with books."

It is stated by Mr. Knight, in his 'Life of Caxton,'* that "We have abundant evidence, whatever be the scarcity of books as compared with the growth of scholarship, that the ecclesiastics laboured most diligently to multiply books for their own establishments. In every great abbey there was a room called the Scriptorium, where boys and novices were constantly employed in multiplying the service-books of the choir, and the less valuable books for the library; whilst the monks themselves laboured in their cells upon bibles and missals. Equal pains were taken in providing books for those who received a liberal education in collegiate establishments. Warton says, 'At the foundation of Winchester College, one or more transcribers were hired and employed by the founder to make books for the library. They transcribed and took their commons within the college, as appears by computations of expenses on their account now remaining.' But there are several indications that even kings and nobles had not the advantage of scholars by profession; and, possessing few books of their own, had sometimes to borrow of their more favoured subjects. . . . . We learn from another source that the great not only procured books by purchase, but employed transcribers to make them for their libraries. We find from the manuscript expenses of Sir John Howard, afterwards Duke of Norfolk, that in 1467 Thomas Lympnor, that is Thomas the Limner, of Bury, was paid the sum of fifty shillings and two pence for a book which he had transcribed and ornamented, including the vellum and binding. The limner's bill is made up of a number of items—for whole vignettes, and half-vignettes, and capital letters, and flourishing and plain writing."

These transcribers and limners worked principally upon parchment and vellum, for the use of paper was by no means extensive until the invention of the art of printing. Some of the old manuscripts contain drawings representing a copier or transcriber at work, such as that sketched in Fig. 1384: where the monk is represented as provided with a singular and tolerably complete set of apparatus to aid him in his work. The desk for containing the sheet or skin on which he is writing, the clasp to keep this sheet flat, the inkstand, the pen, and the knife, the manuscript from which the copy is being made, the desk for containing that manuscript, and the weight for keeping it in its place—all are shown, with a clearness which, despite of bad perspective, renders them quite intelligible. The Egyptian transcriber (Fig. 1382), or rather scribe, seems to be rather less conveniently supplied with writing apparatus.

Of the two substances, parchment and vellum, employed for such purposes before the invention of paper, a word or two may be said. Parchment is made from the skin of sheep or lambs; vellum, from that of very young calves; but the process of preparing is pretty much the same in both cases. When the hair or wool has been removed, the skin is steeped in lime-water, and then stretched on a square frame in a tight manner. While so stretched, it is scraped on the flesh side with a blunt iron, wetted with a moist rag, covered with pounded chalk, and rubbed well with pumice-stone. After a time, these operations are repeated, but without the use of chalk; the skin is then turned, and scraped on the hair side once only; the flesh side is then scraped once more, and again rubbed over with chalk, which is brushed off with a piece of lambskin retaining the wool. All this is done by the skinner, who allows the skin to dry on the frame, and then cuts it out and sends it to the parchment-maker, who repeats the operation with a sharper tool, using a sack stuffed with flocks to lay the skin upon, instead of stretching it on a frame.

* Knight's Weekly Volume—'William Caxton.'

Respecting the quality, value, and preparation of parchment in past ages, it is stated in the 'Penny Cyclopædia' that parchment from the seventh to the tenth century was "white and good, and at the earliest of these periods it appears to have nearly superseded papyrus, which was brittle and more perishable. A very few books of the seventh century have leaves of parchment and papyrus mixed, that the former costly material might strengthen and support the friable paper. About the eleventh century it grew worse; and a dirty-coloured parchment is evidence of a want of antiquity. This may possibly arise from the circumstance that writers of this time prepared their own parchment, and they were probably not so skilful as manufacturers. A curious passage from a sermon of Hildebert, Archbishop of Tours, who was born in 1054, is a voucher for this fact. The sermon is on the 'Book of Life,' which he recommends his hearers to obtain. "Do you know what a writer does? He first cleanses his parchment from the grease, and takes off the principal part of the dirt; then he entirely rubs off the hair and fibres with pumice-stone; if he did not do so, the letters written upon it would not be good, nor would they last long. He then rules lines that the writing may be straight. All these things you ought to do, if you wish to possess the book which I have been displaying to you." At this time parchment was a very costly material. We find it mentioned that Gui, Count of Nevers, having sent a valuable present of plate to the Chartreux of Paris, the unostentatious monks returned it with a request that he would send them parchment instead."

Introduction of Paper: Paper-making.

The circumstances wherein paper mainly differs from all the other materials on which writing has been done, is that paper is a composition, made up from substances which would otherwise be regarded as useless. It was a happy thought—let who will have suggested it—to employ rags, after they had gone through their term of service as garments, for producing this invaluable material. The principle, however, does not depend on the rag-like form of the commodity from whence the paper is made; for textile fibres in any state can be employed, with more or less completeness.

Much discussion has arisen concerning the time and place when paper was first made from a paste composed of vegetable fibre; but it is now believed that China was the country. Silk fibres, and woollen fibres, the stalk of the nettle, the tendrils of the vine, the bine of the hop—all may be, and have to a greater or less extent, been employed in a pulpy state to produce paper; but all are now more or less objectionable; and flax, hemp, and cotton continue to be what they have always been, the materials best calculated for this purpose. About the seventh century, paper made of silk or cotton, or a mixture of both, was made at Samarcand, at Mecca, and at other parts of the East; but it still remains a question where and by whom paper was first made from flax and hemp. Flax paper was known in Spain about the end of the twelfth century, and in France a century later; but the examples of its use are so very rare, that little can be proved from them. Conflicting accounts have been given of the relative share of honour due to France, Italy, Germany, and Holland, respecting this matter; but it appears plain that England was indebted to foreign countries for her paper wholly, down to about the time of Henry VIII., and principally for two centuries afterwards. Fuller, writing in 1662, characterises the paper of his day thus:—"Paper participates in some sort of the character of the country which makes it; the Venetian being neat, subtle, and court-like; the French light, slight, and slender; and the Dutch thick, corpulent, and gross, sucking up the ink with the sponginess thereof." And he complains of the "vast sums of money expended in our land for paper out of Italy, France, and Germany, which might be lessened were it made in our nation."

There are three stages in the manufacture of paper from cotton or linen rags—the conversion of the rags into a pulp, the formation of a thin layer or stratum from this pulp, and the drying of the layer into the form of a sheet of paper: all of which are very interesting processes, whether conducted by hand or by the beautiful machinery invented for that purpose.

The refuse linen and cotton rags procurable in our own country are far too small in quantity for the requirements of the English paper-manufacture; and a supply has therefore to be obtained from foreign countries. Many of the continental states, as a means of encouraging the manufacture of paper at home, prohibit the exportation of rags from those countries; and in this way France, Holland, Belgium, Spain, and Portugal, are closed to us. The markets of Italy and of Germany are, however, available; and our paper-makers derive a large part of their supply from the ports of Leghorn, Ancona, Messina, Palermo, Trieste,

Bremen, Hamburg, and Rostock. The rags are bought in closely packed bales, containing about four hundredweight each, and are divided into several kinds: those from Sicily are dirtier than any others, while English rags are cleanest of all—a difference which tells favourably of the cleanly habits of the mass of persons in our country. The Sicilian rags are in such a state that they require to be washed in lime-water before they are packed and shipped for England.

When the rags arrive at a paper-mill, they are removed from the bales, and taken to a room where females cut them up and sort them. Each female is provided with a wire-top table, on which all the rags are placed in succession; she separates them into qualities, puts all the seams and stitched parts by themselves, shakes the rags so as to make any dirt fall from them through the wire meshes of the table, and cuts them up into pieces three or four inches square. The rags, which generally appear very dark and discoloured, are removed from the sorting-room in bags, and carried to the washing-room. They are boiled in lime-water in large vessels for a considerable time, until they have undergone a bleaching action.

Then ensue the maceration and shredding of the rags into the state of pulp. Until the modern improvements in the paper manufacture, the rags were washed by hand, placed wet in closed vessels till half rotten, and then beat to a pulp by hammers or by rollers; but in the modern "paper-engine" the process is much more effectually and speedily performed. This engine (Fig. 1399) is an oval cistern about ten feet long by half as much in width, made of wood lined with lead. There is a partition running nearly from end to end; and in one of the divisions thus formed there is an iron roller nearly two feet in diameter, having a number of knife-edges projecting radially from it. The rags are put into this trough, water is admitted by the pipe seen at the left hand, and the roller is set in motion. The rags are caught by and are carried round with the roller; and when they come beneath it, they have to pass between the knife-edges of the roller and another set of knife-edges, on a plate beneath it, so that by the meeting of these successive series of edges, the rags become chopped up into an infinite number of small fragments. The degree to which this action is carried, according to the kind of paper to be made, may be regulated by the distance between the respective cutting-edges. In most cases the first stage is to bruise the rags, previous to a thorough bleaching by means of chlorine; and after this a further stage consists in placing the rags in a second engine, where, by a quicker movement and a closer action of the knives, the rags are brought to the state of a perfectly equal and minutely-divided paste or pulp, which is combined with so much water as to reduce it nearly to the consistence of milk. For some kinds of paper, size is added to the pulp, while for other kinds it is applied when the sheets have been formed.

This bleached and smooth pulp then passes to the hands of the paper-maker, whose occupation requires a very large amount of tact and nicety. The pulp, or "stuff," is conveyed into a sort of vat; where it is agitated by machinery, and kept warm by steam brought to it through a pipe. Two men work together at the paper-making processes—one called the "vatman," and the other the "coucher;" and they are provided with the apparatus seen in Fig. 1417. The vatman makes use of two moulds, which are slight frames of wood covered with fine wire, and fitting to each mould is a "deckel," or raised edge, whose position determines the size of the sheet of paper to be made. He places the deckel on one of the moulds, and dips the latter into the pulp, so as to take up a very thin layer of it; he then hands the mould to his fellow-workman, who proceeds with the operations while the vatman is making a second dip into the pulp. The coucher turns the mould over, and makes the thin layer of pulp fall on a piece of flannel; he places another piece of flannel or "felt" on the pulp; and is then ready to receive a second layer from the vatman. Thus the two workmen proceed; the one collecting thin layers of pulp from the vat, and the other interleaving these layers with pieces of flannel. It must be obvious that these operations require great care, especially on the part of the vatman, since he has to determine the quantity of pulp taken up at one time according to the thickness of the sheet of paper to be made. When six or eight quires of paper are thus made, the heap, with the flannels between the layers, is subjected to great pressure. After this the heap is opened, and all the sheets are found to be sufficiently coherent to hold together without the aid of the felts; the latter are removed, and the sheets of paper, being placed one upon another, are moderately pressed. The sheets are next parted, dried, sized, dried again, pressed, examined, and finally made up into quires.

The above description relates to the manufacture of paper by hand; but the most extensive and remarkable system is that in which machinery does nearly all the work; a system which may be briefly described in the following manner:—

The rags are sorted, washed, bleached, cut up, and made into pulp, much in the same way for machine-made as for hand-made paper; but the difference between the two methods commences from the point where the pulp is put into the vessel where it is to be used. The complicated machine sketched in Fig. 1411 is that by which the paper is made. The pulp is put into the circular vessel seen at the left hand of the cut, and from thence it passes onwards by a series of beautiful movements, until it leaves the machine in the state of a perfect sheet of paper, after an interval of only two minutes!

In the first place, the pulp, while kept in constant agitation, is allowed to flow in a continuous stream into another vessel, so as to keep the latter always filled to the same height. It flows from the second vessel upon a narrow wire-frame, where it is sifted or strained through meshes, and then runs over a projecting edge in the state of a broad sheet or film. It is received upon a plane flat surface five or six feet in length, which surface is travelling slowly onward; and the relative velocities of the different movements are so managed, that the pulp arranges itself on the flat plane in a film or layer just thick enough for the paper required to be produced. The flat plane is not solid, but consists of a wire webbing, through the meshes of which some of the water from the pulp passes; so that by the time it has travelled on to the further end of the plane, the pulp has acquired stiffness enough to retain its shape in the film. A wire cylinder then presses upon the moist and tender film; and immediately afterwards another cylinder having wetted felt at the surface, subjects it to a second pressure; by these two actions, the film becomes in great measure flattened, smoothed, and consolidated, so as to have something the appearance of a wetted sheet of paper. The sheet travels along an endless web of wet felt or flannel, which absorbs a good deal of the moisture from it; then it passes between two rollers, which compress it powerfully; then it passes over another web of felt, which absorbs more moisture; and then it is again pressed between two rollers. All these successive stages bring the film more and more into the state of a sheet of paper. A small roller next guides it over the polished surface of a large heated cylinder, by which it is partially dried; then over a second, and then over a third. The paper becomes not only dried, but smoothed and polished, by these pressings, and is then finished. It is, however, endless, that is, it is not divided into sheets; and to effect this division the paper is wound in a large coil on a roller, and severed by the action of a peculiar knife, in the machine sketched in Fig. 1414.

All these movements and processes are exceedingly beautiful. There is no division of the thin film while upon the machine; it is one film from end to end, but in different states at different parts of the machine. One part is flowing in a liquid sheet on the wire-table or plane, while other portions are, at the same instant of time, travelling along this table, passing under the wire cylinder and the felt cylinder, travelling up the first and the second webs of felt, undergoing compression between the first and second pairs of rollers, passing over the first and the two following heated cylinders, coiling round the reel or roller, and being cut up into sheets. In one part it is a white liquid, at another it is a perfectly dry and smooth sheet of paper; and at other intermediate parts it is in an intermediate state. Yet it is all one piece; and the most liquid portion of it has only to undergo a two-minutes' process to be finally completed. This machine is certainly one of the triumphs of mechanical art.

Quill Pens: Metallic Pens.

We find, then, that paper, which may perhaps be regarded as the most important material for writing, is composed of linen or cotton rags, beat up to a pulp, and then formed into thin layers, either by the dexterous work of men's hands, or the still more dexterous action of a machine. Next may be taken into consideration the small implements whereby the writing is effected.

The quills belonging to the feathers of birds seem to have been the most successful and fitting of all materials for pens; for, though steel and other metals are now used for this purpose to an immense extent, there is a power of adaptation in a quill-pen which has never yet been equalled in metal. Quills, however, like other things, have a tendency to "wear out;" and the trouble resulting from the necessity of frequently mending quill-pens has been the main cause of the introduction of steel substitutes. A kind of affection has often been felt by an author or his admirers for the pen with which he has written any large or celebrated work. Old worn-out pens have been preserved as memorials in connexion with such matters; and Dr. Holland, who translated Pliny's 'Natural History' in the sixteenth century, recorded an exploit connected with it in the following lines:—

> "With one sole pen I wrote this book,
> Made of a gray goose-quill:
> A pen it was when it I took
> A pen I leave it still."

The quills employed for pens are generally those of the goose, although the crow, the swan, and other birds yield feathers which are occasionally available for this purpose. Each wing produces about five good quills, and the number thus yielded is so small that the geese reared in England could not furnish nearly enough for the demand: hence the importation of goose-quills from the Continent is very large.

The geese are plucked of their feathers three or four times in a year, the first time for the sake both of the quills and the feathers, but the other times for the feathers only. The pen-quills are generally taken from the ends of the wings. When plucked the quills are found to be covered with a membranous skin, resulting from the decay of a kind of sheath which had enveloped them; the interior vascular membrane, too, resulting from the decay of the vascular pith, adheres so strongly to the barrel of the quill as to be with difficulty separated; while, at the same time, the barrel itself is opaque, soft, and tough. To remove these various defects the quills undergo several processes. In the first instance, as a means of removing the membranous skin, the quills are plunged into heated sand, the high temperature of which causes the external skin of the barrel to crack and peel off, and the internal membrane to shrivel up. The outer membrane is then scraped off with a sharp instrument, while the inner membrane remains in a state to be easily detached. For the finest quills the heating is repeated two or three times. The heat of the sand, by consuming or drying up the natural moisture of the barrel, renders it harder and more transparent. In order to give the barrel a yellow colour, and a tendency to split more readily and clearly, it is dipped in weak nitric acid; but this is considered to render the quill more brittle and less durable, and is therefore a sacrifice of utility for the sake of appearance.

When the barrels of the quills are properly prepared for use, the broad barbs on the inner edge are usually stripped off to make the quills lie closer together; and they are then made up into bundles, commonly of twenty-five each, and bound up. Sometimes quills are prepared for pens by dipping the barrel in water, heating it at a charcoal fire, scraping or pressing it flat, and allowing it to swell out again to the cylindrical form: by this means an increased elasticity is given to the pen. The quill-dresser receives the quills in large promiscuous bundles, just as they are plucked from the birds, and he sorts them into various groups according to their qualities. Those of the largest size and longest barrel are called "primes," and are set aside for making the best and dearest pens; the next in point of size and quality are called "seconds;" while the worst are designated "pinions."

The making of quills into pens is one of those mechanical operations which strikingly illustrate the tact acquired by long practice. Some persons never acquire this art, while others conduct it with a degree of rapidity quite astonishing. Some of the persons regularly employed in this way will make nearly a thousand pens in a day. Within the last few years a curious kind of knife has been patented, having for its object the speedy shaping of a pen by simple pressure, after one or two preliminary cuts have been made. The end of the quill is placed in a groove, and a hinged lever or handle is brought down upon it in such a manner that a sharp piece of steel shapes the pen by one act. Another contrivance consists in making several pens out of one quill. The stalk of the quill and also the end of the barrel are cut off, leaving only a cylindrical part of the barrel, pretty nearly equal in diameter from end to end. A small pipe or rod is inserted in this cylinder, and the latter is placed in a machine in such a way that two cutting edges pass along the barrel, one on each side, by which the quill is cut lengthwise into two semi-cylindrical halves. These small pieces are placed, with the concave side uppermost, in a groove, and the edges are made straight and smooth by having a plane passed over them. These half-cylinders are cut into three or four pieces each, and each piece, when nibbed and shaped, forms a pen which can be adjusted to a handle in the same way as a steel-pen.

The use of the "steel-pen" has not sprung immediately from that of the "quill-pen." There were several intermediate stages adopted before the fitness of steel for this purpose was sufficiently known. From about the commencement of the present century, down to ten or a dozen years ago, the number of proposed substitutes for the quill-pen was very considerable. Horn-pens, tortoiseshell-pens, nibs of diamond or ruby imbedded in tortoiseshell, ribs of ruby set in fine gold, nibs of rhodium and of iridium imbedded in gold—all have been adopted at different times, but most of them have been found too costly for general adoption. Steel is proved to be sufficiently elastic and durable to form very good pens, and the ingenuity of manufacturers has been exerted to give to such pens as many as possible of the good qualities possessed by the quill-pens. The number now made annually in England, especially at Birmingham, almost exceeds belief.

The mode in which steel-pens are made differs in different establishments, but the following will give a

1394.—The Almonry, Westminster, formerly Caxton's Printing-office.

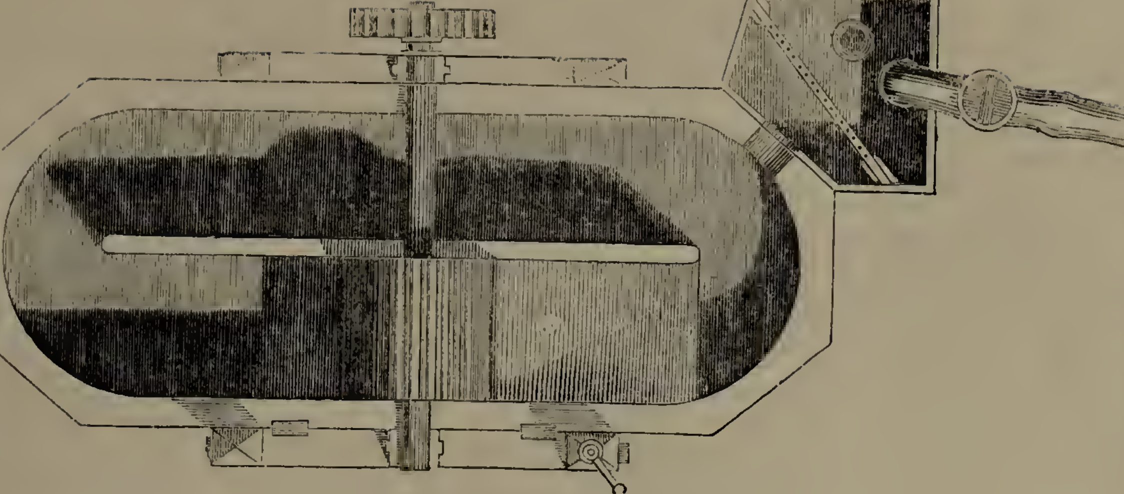
1396.—Statue of John Gutenberg (the inventor of printing by moveable types), at Mayence.

1397.—Bas-relief on Gutenberg's Monument: Examining a Matrix.

1395.—Ancient Dutch Printing-office.

1398.—Bas-relief on Gutenberg's Monument: Comparing a printed Sheet, with a Manuscript.

1.—Early Printers' Marks: Thomas Berthelet.

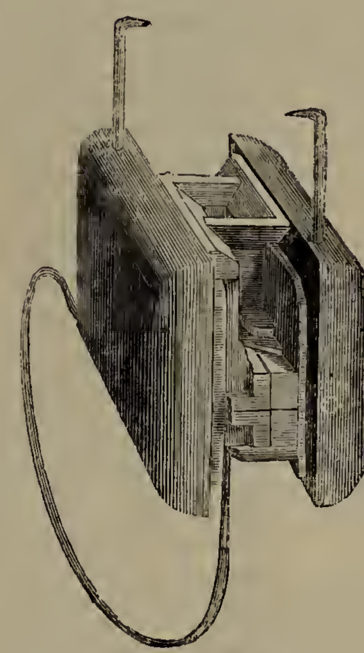


1399.—Plan of Washing-engine: Paper-manufacture.

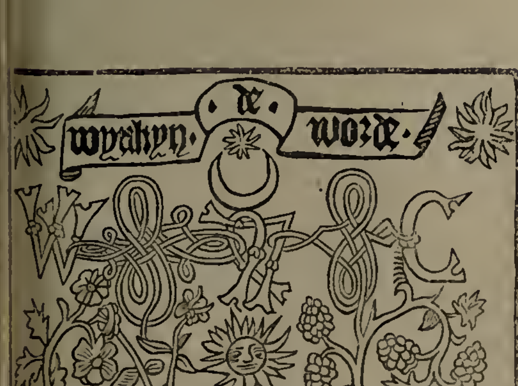
1402.—Early Printers' Marks: Robert Wyer.

1403.—Early Printers' Marks: Richard Pynson.

1400.—Portrait and Memorials of William Caxton, the first English Printer.



1404.—Mould for Type-founding



1405.—Early Printers' Marks: Wynkyn de Worde.

1406.—Early Printers' Marks: John Day.

1407.—Early Printers' Marks: Robert Coplande.

general idea of the process. The steel is rolled into very thin plates, and cut into strips three or four feet long by four inches broad: these strips are annealed, and rolled to the thickness of about one-hundredth of an inch. A stamping-press cuts out pieces of the proper size for pens, with the fibre of the steel running lengthwise of each piece; and a hardened steel punch and matrix, attached to a powerful fly-press, cut the pieces to the outline shape of pens. The shaped pieces are put into an iron box containing tallow, heated in a furnace, emptied out upon hot ashes, and cooled gradually. A chisel with an exquisitely fine edge is brought down upon each piece with such exactness as to make a slit about two-thirds through the thickness of the steel. The other slits are made, the maker's name stamped, and the "dishing," or hollow form, given to the pen by stamping. After this the pens are heated to redness, and quenched in cold oil, by which they become tempered. They are then shaken up together, thousands in number, in a cylinder which has a curious agitating movement given to it; so that, by their mutual friction, they rub each other smooth and bright, and remove the rawness of the edges. They are then tempered and coloured according to the taste of the manufacturer. This will give some idea of the kind of processes whereby the sheets of steel are converted into pens. Eight years ago it was estimated that *two hundred millions* of steel-pens were made in England yearly: at the present time this amount must be largely exceeded.

Black-Lead Pencils: Crayons.

A very useful substitute for the pen, under many circumstances, is that which requires no liquid ink for marking the characters on the paper—such is a black-lead pencil. The peculiar substance which fills the central channel of the stick of cedar has the property of marking when it touches paper; and, as the marks thus made are susceptible of easy removal, a pencil of this kind is available for purposes which would not be answered by the use of pen and ink.

The substance misnamed "black-lead" is a carburet of iron, being composed of carbon and iron. It generally occurs in mountain districts, in small kidney-shaped pieces, varying in size from that of a pea upwards, which are interspersed among various strata. It is met with in different parts of the world, but principally in Cumberland. At Borrowdale, near Keswick, a mine of black-lead was accidentally discovered during the reign of Queen Elizabeth, and it has ever since yielded a large supply of this material. The mineral was regarded as being so valuable that it commanded a very high price, and this price acted as an inducement to the workmen and others to pilfer pieces from the mine. For a number of years scenes of great commotion took place, arising out of these depredations; and the result was that the proprietors adopted such stringent rules that hardly anything was known of the internal economy of the mine till about thirty years ago, when Mr. Parkes gave a description of it, from which we may condense a few particulars.

The mine is in the midst of a mountain about two thousand feet high, which rises at an angle of about 45°; and, as that part of the mine which has been worked during the present century is near the middle of the mountain, the present entrance is about a thousand feet from the summit. The opening by which the workmen enter descends by a flight of steps; and, in order to guard the treasure contained within, the proprietors have erected a strong brick building of four rooms, one of which is immediately over the entrance into the mine. This entrance is secured by a trap-door, and the room connected with it serves as a dressing-room for the men when they enter and leave the mine. The men work in gangs, which relieve each other every six hours; and when the hour of relief comes, a steward or foreman attends in the dressing-room to see the men change their dresses as they come up one by one out of the mine. The clothes are examined by the steward, to see that no black-lead is concealed in them; and when the men have dressed they leave the mine, making room for another gang, who change their clothes, enter the mine, and are fastened in for six hours. In one of the four rooms of which the house consists there is a table, at which men are employed in sorting and dressing the mineral. This is necessary, because it is usually divided into two qualities, the finest of which have generally pieces of iron-ore or other impurity attached to them, which must be dressed off. These men, who are strictly watched while at work, put the dressed black-lead into casks holding about one hundredweight each, in which state it leaves the mine. The casks are conveyed down the side of the mountain in a curious manner. Each cask is fixed upon a light sledge with two wheels, and a man, who is well used to the precipitous path, walks down in front of the sledge, taking care that it does not acquire momentum enough to overpower him. When the cask has been thus guided safely to the bottom, the man carries the sledge up hill upon his shoulders, and prepares for another descent.

Up to about the middle of the last century the mine was opened only once in seven years—the quantity taken out at each time of opening being such as was deemed sufficient to serve the market for seven years; but when, at a later period, it was found that the demand was increasing and the supply decreasing, it was deemed necessary to work the mine six or seven weeks every year. During the time of working, the mine is guarded night and day; and, when a quantity sufficient for one year's consumption has been taken out, the mine is secured until the following year. Several hundred cart-loads of rubbish are wheeled into the mine, so as to block up the entrance completely; and this rubbish acts as a dam to prevent the springs and land-waters from flowing out, so that the mine gradually becomes flooded.

When the year's mining is concluded, the barrels of black-lead are brought to market, and the mode of effecting the sales was described by Dr. Faraday a few years ago to be as follows:—A market is held on the first Monday of every month at a house in London, where the buyers, who are generally only seven or eight in number, examine every piece with a sharp instrument to ascertain its hardness—those which are too soft being rejected. The person who has the first choice pays 45*s.* per pound, the others 30*s.* But, as there is no addition made to the first quantity in the market, the residual portions are examined over and over again until they are exhausted. At one time the annual sale was said to amount to the value of 40,000*l.* per annum, but it has been greatly reduced since.

The above description relates to the Borrowdale Mine rather as it *has* been than as it now is. By the workings of a long series of years, all the best portions of black-lead have become so nearly exhausted that the only kind now obtainable (except in very small quantity) is getting earthy. After being a source of much trouble both to the dealers and to the users, this inferior mineral has been successfully brought under the action of a curious system of machinery, by which it is rendered fit for its required purpose. The arrangements now adopted at an establishment at Maryport are as follows:—

In order to divest the mineral of all the gritty and sandy particles, it is crushed between iron rollers, and blown through a fine sifter as a means of separating the dust. When thoroughly cleaned, it is placed in large iron pots, and mixed with water; three iron balls whirl round in these pots for a long period, until they have reduced the black-lead to the state of a fine powder. When a sufficient degree of fineness has been attained, the powder is packed in small retorts, and submitted to a white heat in a close furnace; it is then, by great pressure, compressed into square blocks, which are cut up into thin slabs of various sizes, to suit different purposes. The crushing, the cleansing, the grinding, the pressing—all are necessary to give the black-lead the required degree of hardness; and this hardness is regulated in practice by the intensity of the pressure.

Another mode of applying manufacturing processes to the preparation of the black-lead is described by Dr. Ure as being adopted in Paris. The mineral, being reduced to a fine powder, is mixed with very pure powdered clay; and the two are calcined in a crucible at a white heat; the proportion of clay employed is greater as the pencil is required to be harder; the average being equal parts of both. The ingredients are ground with a muller on a porphyry slab, and then made into balls, which are preserved in a moist atmosphere in the form of paste. The paste is pressed into grooves cut in a smooth board; and another board, previously greased, is pressed down upon it. When the paste has had time to dry, the mould or grooved board is put into a moderately heated oven, by which the paste, now in the form of square pencils, shrinks sufficiently to fall out of the grooves. In order to give solidity to the pencils, they are set upright in a crucible, and surrounded with pounded charcoal, fine sand, or sifted ashes; the crucible, being covered, is exposed to a degree of heat proportionate to the hardness required in the pencils, the harder pencils requiring the higher degree of heat. Some of the pencils are shaped in a curious manner: models of the pencils, made of iron, are stuck upright upon an iron tray, having edges raised as high as the intended length of the pencils; and a metallic alloy, made of tin, lead, antimony, and bismuth, is poured into the sheet-iron tray. When the alloy has cooled, it is inverted and shaken off from the model-rods, so as to form a mass of metal perforated throughout with tubular cavities corresponding in size with the intended pencil pieces; the pencil paste is introduced by pressure into these cavities; and when nearly dry, the pieces shrink sufficiently to be easily removed from the cavities.

The pencils just described are alike throughout all their thickness; but in the majority of English pencils there is a wooden holder to contain a narrow filament of black-lead running down the middle. So long ago as the year 1618 this mode was adopted; for Sir John Pettus, in his 'Fleta Minor,' while speaking of black-lead, says that "Of late it is curiously formed into cases of deal or cedar, and so sold as dry pencils, something more useful than pen and ink." In a general way, modern black-lead pencils are made by sawing cedar first into long planks, and then into smaller rods; grooves are cut out by means of a cutting-machine moved by a fly-wheel, to such a depth as will receive a small layer of black-lead; the pieces of the mineral are cut into thin slabs, and then into rods the same size as the grooves, into which they are inserted; the two halves of the case are then glued together, and the whole is turned into a cylindrical form by means of a gauge. In cutting the leads for the "ever-pointed" pencils, on Mordan's patent, the mineral is made into a cylinder or rod so small as to require no further cutting or sharpening when in use; and this constitutes the merit of the contrivance. The black-lead is formed into these cylindrical rods by being first cut into thin slabs, then into square rods, and finally passed through holes in a steel plate armed with rubies for the sake of hardness; the first of these holes is octagonal, by which the four-sided rod of mineral is converted into one of eight sides; and other holes are for converting this octagonal form to a cylindrical one.

At the Maryport works the pencils are made by an improved and expeditious process. The cedar is cut up into planks, slabs, and rods, by a steam-worked saw. An engine then shapes the pencil-sticks and makes the grooves at the same time. The black-lead is cut up into slabs; these slabs are made into slender rods, the rods are glued into the wood, and the two halves of the wood are glued together; the square form of the wood is exchanged for a cylindrical one, and the pencil is finished. The principle is much the same in the new and the old method, but the former is more complete in the details.

The kind of pencil called "crayon" is a mixture of some kind of earth with a colouring substance. The earth employed is sometimes chalk, and at other times pipe-clay, gypsum, starch-flour, or ochre. The colouring substance is yellow ochre, mineral yellow, chrome, red chalk, vermilion, indigo—indeed, any of the usual dry colours, according to the tint required. Besides the earth and the colour, there is a gummy liquid required to combine them together; gum Arabic, gum tragacanth, and in some cases oil, wax, or suet, are used as the third ingredient. The earth selected is ground up with gum-water to the required consistence; and the colour employed is separately ground up in a similar way: after which the two are mixed. When the proper tint is produced, the paste is worked up into the oblong cylindrical form which crayons usually present, by the following stages:—It is first dried a little between sheets of unsized paper; and when the excess of moisture is thus absorbed, the paste is divided into small masses. These masses are formed into balls between the palms of the hands, and then rolled to and fro by the hand on a flat smooth table or wooden plank; there are two small parallel rods or bars fixed to this plank, of such thickness as to regulate the diameter of the cylinder into which the paste is rolled; and when the diameter is approaching nearly to this limit, a flat piece of wood is substituted for the hand, with which the process of rolling is brought to a conclusion. The cylinders thus formed are then cut with a knife into pieces of the proper length for crayons; and, when dry, they are pointed at one or both ends with a knife. The crayons here alluded to are employed rather for drawing than for writing; but they obviously belong to the class of pencils in their mode of action.

Ink: Indian Ink: Water-Colours.

The use of a liquid is a necessary accompaniment to a pen, and in so far the latter is less convenient than a black-lead pencil. But the durability of ink renders an advantage which for many purposes far outweighs this minor defect. Hence the preparation of an ink, or writing and printing fluid, has become an important matter in connexion with the subject. We have in a former page given a few details concerning the kinds of ink used by the ancients, and by some of the Oriental nations in the present day. In our own country the kinds are mainly two, one for printing and the other for writing—the distinction of the latter into "black" and "red" being a subordinate one.

Printing ink contains oil; whereas writing ink does not. The former is made principally of oil and carbon, and has the property of adhering with much firmness to the surface of moistened paper—indeed, the adhesion is so strong that it would require chemical processes of great nicety to separate one from the other. Oil is boiled in a cauldron until it loses a great deal of its greasy quality; and the ink-maker provides two kinds of this "varnish" (as the boiled oil is called) having different degrees of thickness or consistence; since the state of the weather and the kind of type influence the thickness of the ink required in printing. For making black printing ink, the varnish is mixed with lamp-black; for red ink with vermilion. The varnish and the colouring material are ground up well together; and one or other of some other materials is generally added, including turpentine, resin, soap, and treacle. The ink used for printing from copper or steel plates, or

from lithographs, is much the same in quality as that for press printing, but is less viscid.

The ink made for writing is far more diverse in character than printing ink, since the requisite qualities can be obtained from among a much larger choice of ingredients. Hence recipes for ink-making are very numerous, and it would be impossible to state one that would apply to all. One mode of preparing it will suffice to illustrate its general character:—Eight ounces of Aleppo galls are pounded, and, together with four ounces of logwood chips, are boiled for about an hour in twelve pounds of distilled water; the decoction is strained through a hair-sieve, and to it are added four ounces of sulphate of iron, three ounces of pounded gum-arabic, one ounce of sulphate of copper, and one ounce of sugar-candy; the mixture is stirred until the gum is dissolved, and, after standing to settle, the clear portion is poured off into another vessel, where six drops of kreosote are added to prevent mouldiness.

Red writing ink receives its colour from cochineal, or logwood, or Brazil-wood, combined with other chemical agents; many modes being available for producing the requisite tint. Many different kinds of ink, called for distinction "writing fluids," are so prepared as to yield a blue colour when first used, with a tendency to change to a jet black afterwards. Other inks, such as are employed for "marking" on linen, are made with a peculiar reference to some chemical affinity or action between two or three liquids. Thus, when an ink is prepared of nitrate of silver, gum-arabic, Indian ink, and distilled water, if writing be effected with this on a piece of cloth it becomes indelible; but the cloth requires to be prepared for this by being previously dipped into a liquid formed of carbonate of soda, gum-arabic, and water, and then dried. Numerous varieties of these "marking inks" are sold, having very unequal degrees of merit. Again, there are liquids which obtain the designation of "sympathetic" or "secret" inks; that is, they are inks which may be made either visible or invisible, at the pleasure of the correspondents. In nearly all these cases the paper is steeped in some chemical liquid to aid the object in view; sometimes, when writing has been made with one liquid on paper which had previously been steeped in another, the writing becomes visible only when held before a fire; in other cases the paper requires to be washed with a particular liquid after the writing, in order to render the latter visible. All such contrivances depend on the chemical relations between the liquids employed, and will become more and more numerous as chemistry advances—whether they are worth the trouble is another question.

"Indian ink" (or, as it ought rather to be called, "China ink") is a kind which has long been known and used in this country for drawing rather than writing. It is used in China with a brush, both for writing and for painting upon paper of Chinese manufacture. The cakes of this ink are made of lamp-black and size or animal glue, with the addition of perfumes or other substances not essential to its quality as an ink. The common lamp-black is not fitted for this purpose, since the materials require to be of the very best kind, and prepared with much care. When properly made, it possesses great advantages in drawing, since it acts as a paint, which will give any desired degree of blackness according to the quantity of water mixed with it.

While speaking of inks and coloured liquids, a few words may be said of the colours used in "water-colour" painting. These are made of a large variety of animal, vegetable, and mineral substances—chiefly the last of the three. Cochineal, the lac-insect, madder, indigo, verdigris, verditer—all the customary colouring ingredients, under certain restrictions, are applied to this purpose. The substances require a much more careful preparation than when intended for the coarser kinds of painting; they are ground to a state of minute division, and are mixed up with water, or gum, or some other liquid to the state of a smooth paste, which is cast in a mould, and made to assume the form of a cake.

A few of the colours employed in this way are very costly; such as "carmine" and "ultramarine." The former of these is prepared in a curious way from the cochineal insect. In some districts of Mexico there are "Nopaleries," or plantations for the rearing of these insects. These insects prefer, before all other kinds of food, the sap of a kind of prickly pear-tree called the nopal; and the Mexicans plant this tree on purpose to afford sustenance to the insects. The insects adhere to the leaves, and feed upon them, much in the same way as the silk-worm does in respect to the mulberry. When they have eaten till they appear ready to burst, the insects are removed from the leaves by a blunt knife, and kept for a short time in earthen pots. They are then killed in one of three ways: by immersion in hot water; by exposure to fire; or by the action of the heat of the sun. When dried, the insects are sold to colour-makers, who derive a beautiful scarlet or crimson colour from them. There is a rich colouring matter contained within their bodies; and this colour may be extracted by solution with water or by decoction with alcohol. When extracted, it is applied to the preparation of "carmine," of "rouge," of "scarlet," of "lake," and other colours, according to the substances with which it is mixed and the mode of its preparation.

Ultramarine is a substance which presents a blue colour of an intensely vivid character, and almost imperishable and unchangeable. It is prepared from the "lapis lazuli," or "lazulite," a mineral met with in small quantities in certain species of rocks. A French writer on this subject, M. Patrin, states that when he was at Ekaterinburg, in Siberia, he met with a dealer in precious stones, who had been in Bokhara, from whence the most beautiful specimens of lazulite are obtained; and he took that opportunity to learn the nature of the mountain rocks in which this mineral is found. The dealer told him the mineral occurred in granite; that it was not disposed in veins or filaments, but disseminated through the entire mass of the rock in all sorts of proportions; that nothing was perceived but light blue patches or spots upon a rock which was in other respects grey; that these spots were of an intensely vivid colour; that some of the spots were less mixed up with foreign ingredients than others; and that the masses found were very varied in size. The mineral is quarried from the rock, and is sold in fragments to dealers, who in their turn devote them to various purposes. The finest specimens are regarded as gems, and are worked up into ornamental forms: the less beautiful pieces are consigned to the hands of persons who procure a colouring substance from them. The mode devised by Kunchel, a German chemist, for this purpose, was the following:—After having broken the lazulite into small pieces, he calcined it and quenched it in vinegar. He then pounded it in a porphyry mortar, moistening it from time to time with vinegar or spirits of wine; the pounding being continued until the mineral was reduced to an impalpable powder. This powder was mixed with half its weight of virgin-wax and of colophine, and melted in a glazed earthen vessel. The melted mixture was put into a piece of linen cloth, and immersed in a glass vessel containing warm water; and on squeezing the linen bag, a coloured liquid exuded through the pores. When the water had become strongly coloured, the mixture was taken out and immersed in a second glass of water, by which a colour of less intensity was obtained; a third and a fourth time this was repeated, till the contents of the bag yielded no more colour; and each portion of water was allowed to deposit the colouring matter, so that the latter might be dried for use as the costly colour "ultramarine."

Most of the other kinds of water-colours are less difficult of preparation, and less costly, than the above two.

Sealing-Wax: Wafers.

There are two other little appendages to the writing-desk which call for a short notice, viz. *sealing-wax* and *wafers*.

With respect to the custom of sealing letters in past times, Fosbrooke says:—"Impressions in gold, silver, and lead occur in Trajan and the other Roman emperors in Ticoroni; among the Christian emperors, bishops, &c.; in the west, Spain, Sicily, Italy; and in the south, but not the north of France. The *Terra sigillaris*, or sealing earth, which was rather a bitumen, was brought from Asia by the Romans, and was first known, says Beckmann, among the Egyptians, and the specimens are seemingly all enclosed in leaden cases. Pipe-clay was also used, as well as maltha, a cement of pitch, wax, plaster, and fat." When wax, properly so called, became adopted for these purposes, the colour was very diversified at different times and in different countries. Thus, the emperors and princes of Germany, from Otho I. to Frederick IV., used white wax in sealing their state documents, while in after periods coloured wax was used: white was generally used by the kings of England down to Charles I. Yellow wax has been occasionally used in English state documents. The emperors and patriarchs of the East often used green wax. Black wax was used by the grand masters of the Maltese and Teutonic orders. All these are matters which, like mere "fashion," have fluctuated with no better reason than the shape and colours of garments.

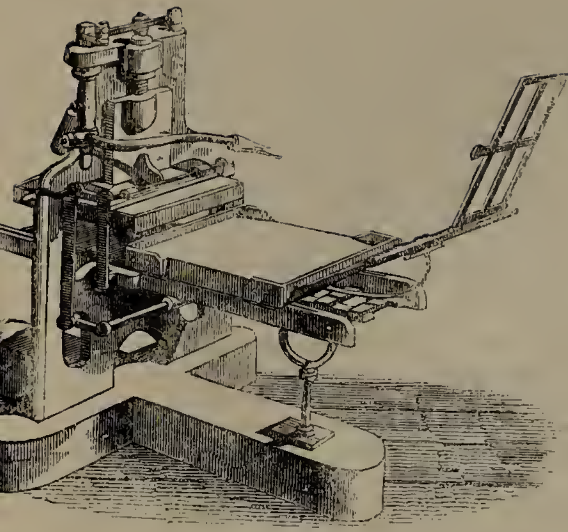
The wax employed for official purposes has given a name to that which is in everyday use; for, in strictness, the latter cannot be properly designated wax, whereas the former can. The large seals employed by the lord chancellor and other officers of state are made of a substance composed by melting block white wax with one-fourth of its weight of Venice turpentine, and colouring it with vermilion for red, or with verdigris for green; the melted mixture is poured on a melted slab, and then formed into rolls. The sealing-wax in common use, however, contains no wax; it is, if well made, formed of gum-lac and Venice turpentine; but the cheaper kinds are made of commoner resinous ingredients. Why it is that sealing-wax has been so often designated "Spanish wax," is not very easy to explain, for the Spaniards have neither been in the habit of supplying the ingredients nor making the wax. The Dutch were long the most celebrated sealing-wax makers; and Beckmann gives an extract from a Dutch work, published in 1579, where instructions are laid down for making sealing-wax, "with which if letters be sealed, they cannot be opened without breaking the seal." The Dutch wax has often had on each stick the legend "BRAND WELL EN VAST HOUD" (burns well and holds fast); and the English makers used to copy this legend on the wax made in this country, but this latter custom is not now so much acted on.

Sealing-wax is made somewhat in the following way:—Four pounds of light-coloured shell-lac are mixed with a pound of Venice turpentine, and three pounds of vermilion. The ingredients are melted and stirred well together; and when set, a quantity of the mixture sufficient to make six sticks is weighed and set apart. The sticks are made on a marble slab, under which is a chafing-dish to keep it properly heated. The wax is rolled on this slab with the hand until it is brought to a roll, nearly the length of six sticks; after which the proper length and thickness are exactly attained by rolling it with a square piece of hard wood. The stick is then given to another workman, who rolls it upon a cold marble slab with a marble roller until it is quite cold, and then polishes it by holding the stick between two charcoal fires, placed at a small distance opposite each other, until the surface has become smooth by being partially melted. As the long stick hardens, five deep indentations are made in it, by which it is divided into six equal lengths; and these lengths are finished by first holding the ends to the flame of a lamp, and then stamping the maker's name or other device with a heated stamp.

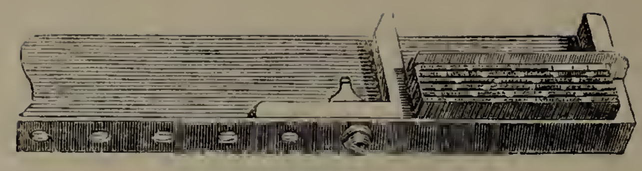
The above alludes to wax of the best kind, and of a red colour. If other coloured wax be required, some other colouring substance is used instead of vermilion: such, for instance, as verditer or smalt for blue, ivory-black for black, masticot or turbeth for yellow, &c. Some kinds have a golden hue imparted to them by the admixture of powdered yellow mica. Sometimes the sticks have an oval, a grooved, a channelled, or an ornamental shape given to them; in such case the wax is cast in moulds. Some varieties are rendered fragrant by the addition of ambergris, musk, or some other scent. The common sealing-wax sold about the streets at a cheap price contains common resin instead of gum-lac, red-lead instead of vermilion, lamp-black instead of ivory-black, and common turpentine instead of Venice turpentine: this would be fair enough, if the purchaser knew what he was buying, and paid for it accordingly; but a deception is sometimes practised, by softening a stick of this inferior wax, rolling it in powdered wax of a better quality, and polishing this artificial surface, so that it may mask the inferior substance within.

Wafers, as a ready substitute for sealing-wax, have been much in use within the last few generations; but it is not clearly known when and by whom they were first employed. A red wafer has been found on a letter bearing date 1624; and nothing is known of the use of these little contrivances before that date. A wafer is a paste so prepared that it may assume a dry form when for sale, and may be quickly softened when required to be used. A mixture is made up of fine wheaten flour, isinglass, and white of egg; this mixture is spread out on flat plates, and subjected to gentle pressure, to reduce the layers to the proper thickness. Several tin plates, with the layers on them, are piled one on another, and put in an oven, where the heat of the air and the pressure of the plates combine to give a smoothness, hardness, and polish to the layers of paste. The layers are received from the tins, and placed one upon another to the thickness of an inch. A punch then presses upon the layers with sufficient force to penetrate the whole pile; and thus as many wafers are made by one punching as there are layers in the pile. While the paste is being mixed, previous to the process of drying, the colouring ingredient is added, which may be vermilion, red-lead, smalt, or any of the usual kind.

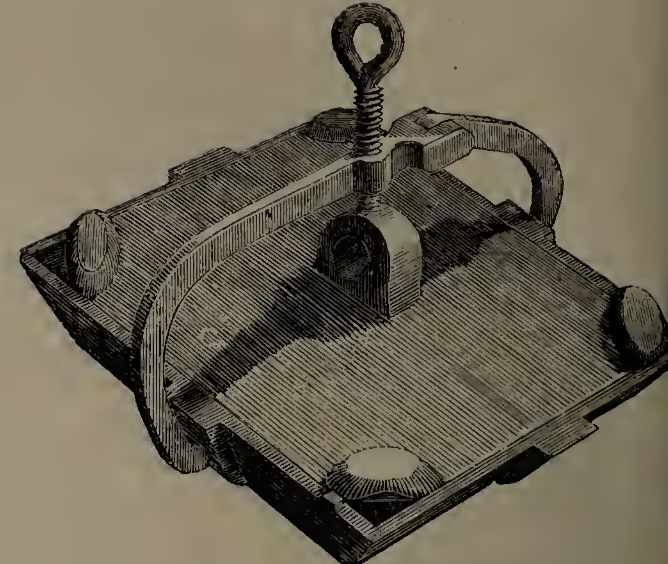
A good deal of ingenuity has been shown within the last few years in devising new kinds of wafers. One kind, called the "medallion" wafer, is intended to be used more like a seal than like a wafer, and is thus made:—A gem or medallion is engraved with any fanciful device, and this is employed to give the distinguishing character to the wafer. A thick solution of glue, coloured to any desired tint, is prepared; and another solution of gum, thinner than the other, and either rendered white or coloured. The seal is wetted with the gum-water, which is allowed to remain in the depressed part of the device, but is wiped off from all the plane or projecting parts. A small portion of the coloured glue is poured on the seal, and allowed to dry on in the form of a film. This film constitutes the ground of the wafer, and may be either white or coloured; and the gummed portion constitutes the device, which may in like manner be either white or coloured. When the wafer is to be used, the back of it is slightly moistened, by which the glue is sufficiently melted to adhere firmly to the letter.



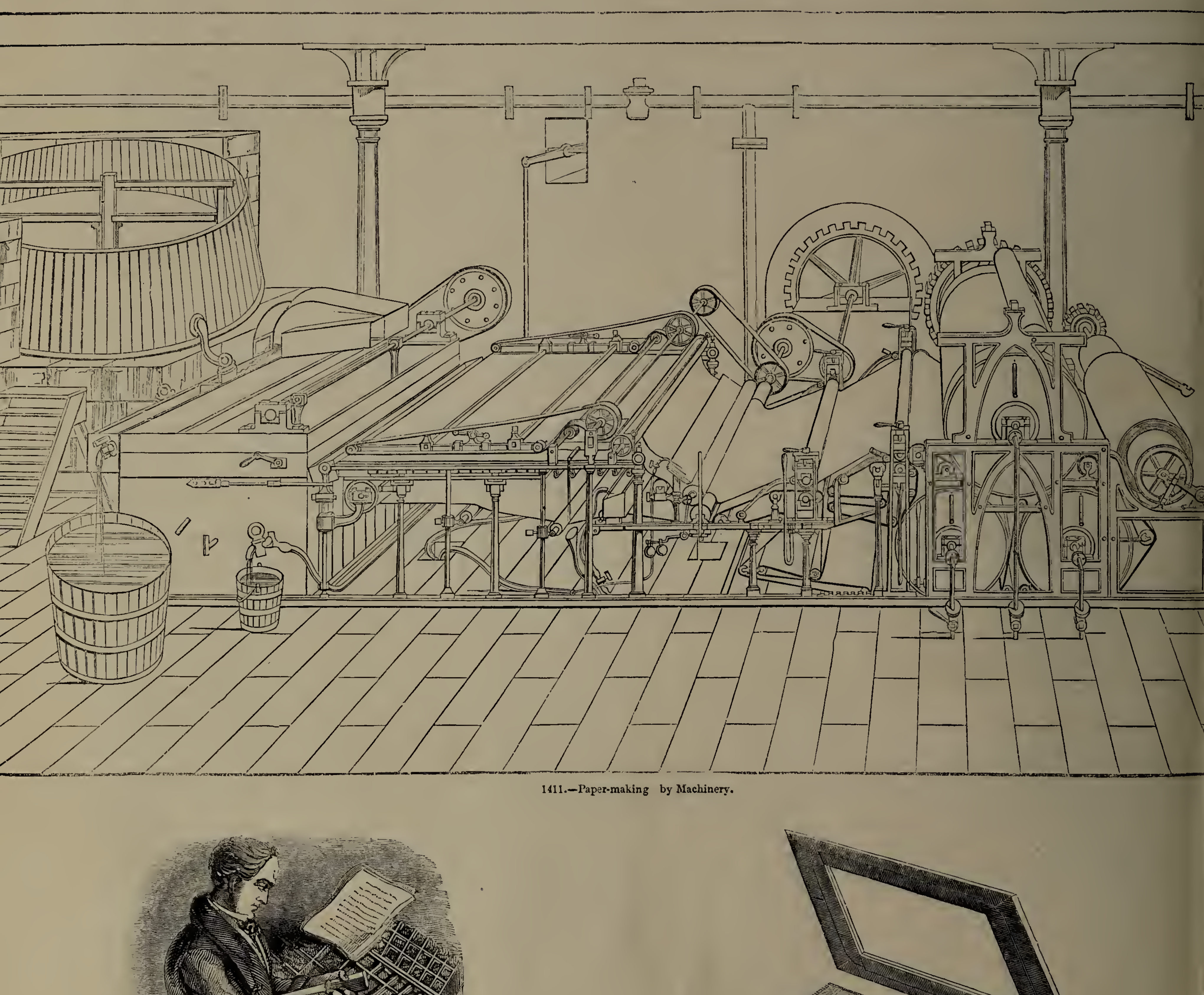
1408.—Stanhope Press.



1409.—Printer's Composing-stick.



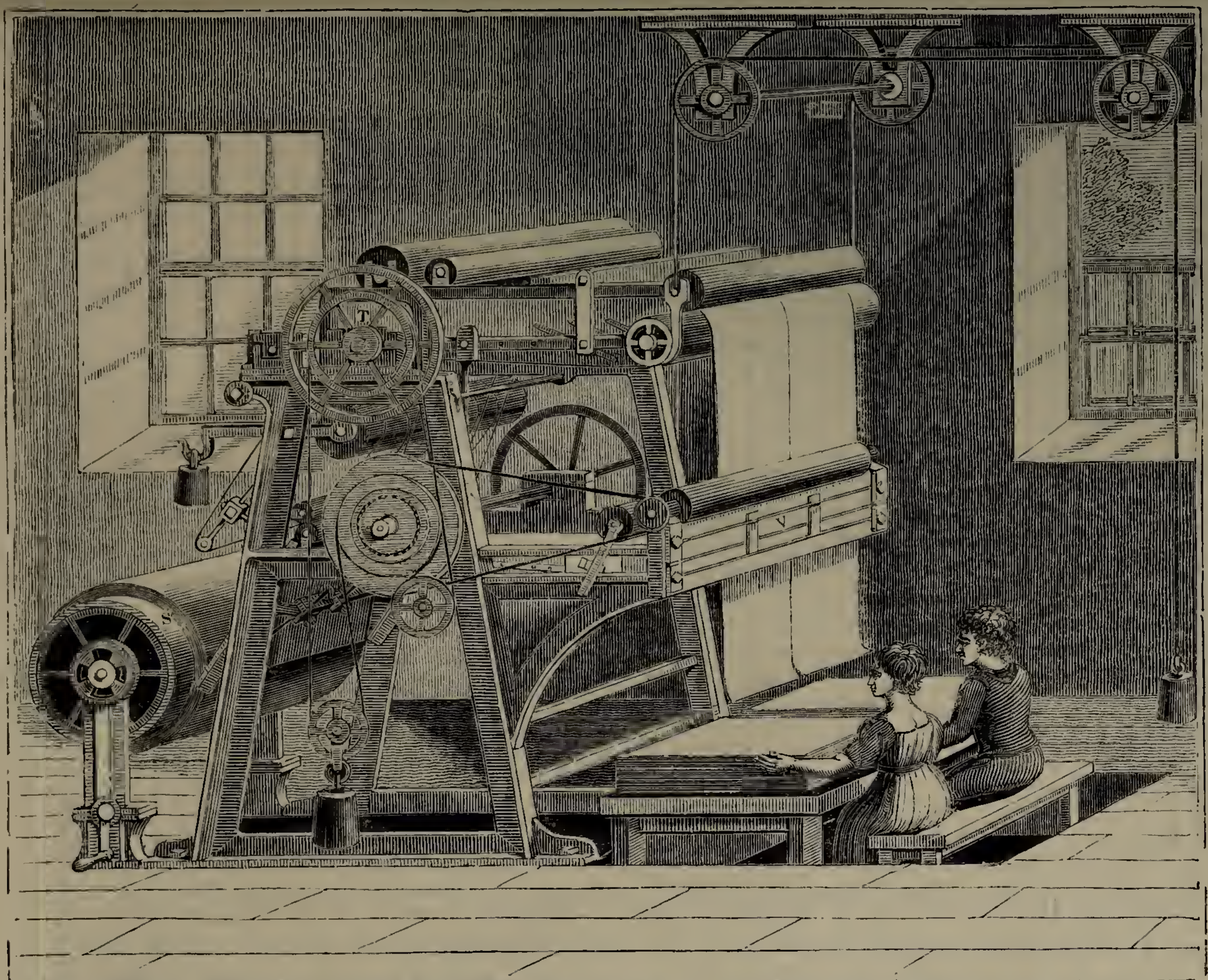
1410.—Stereotype Casting-box.



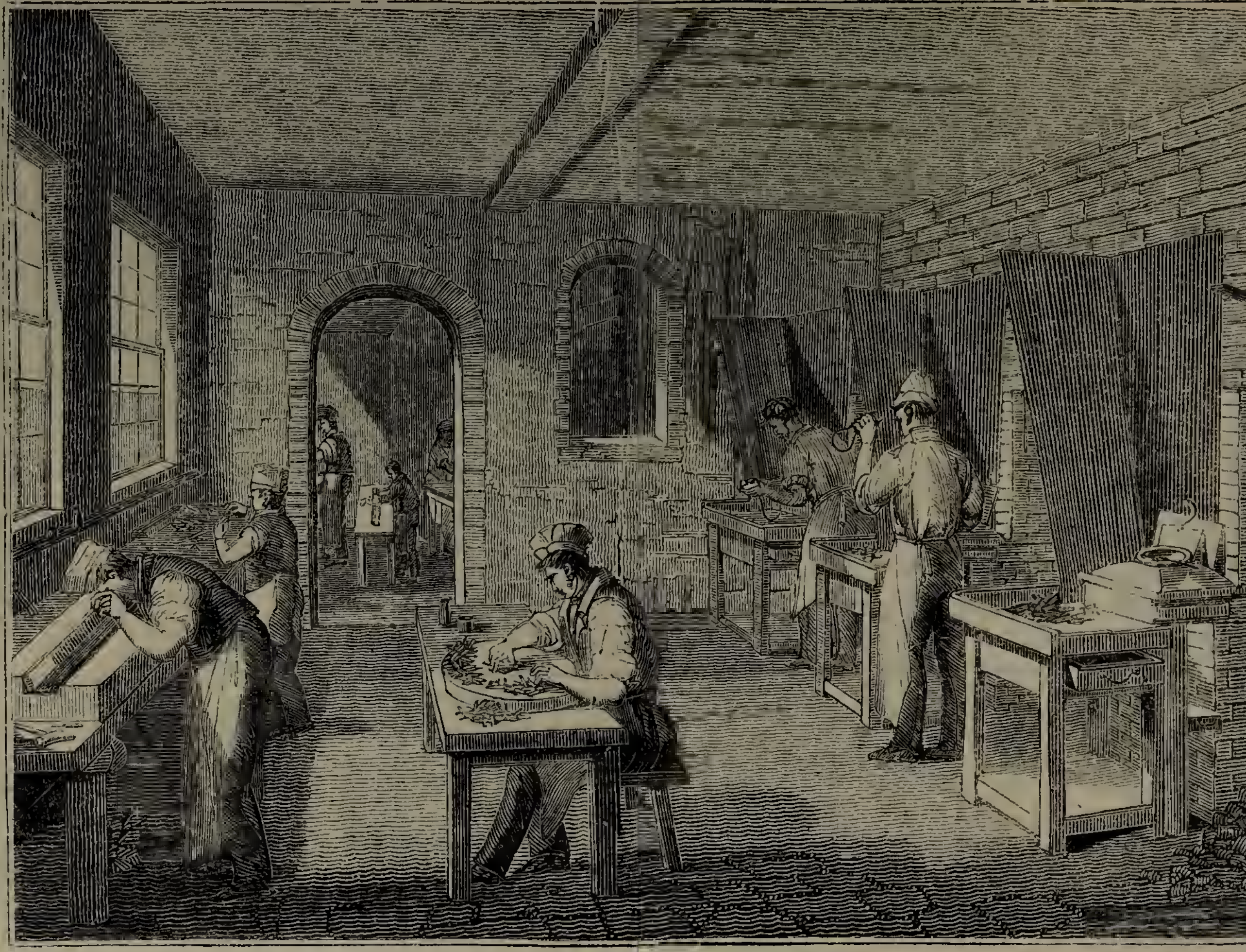
1411.—Paper-making by Machinery.

1412.—Compositor at Work.

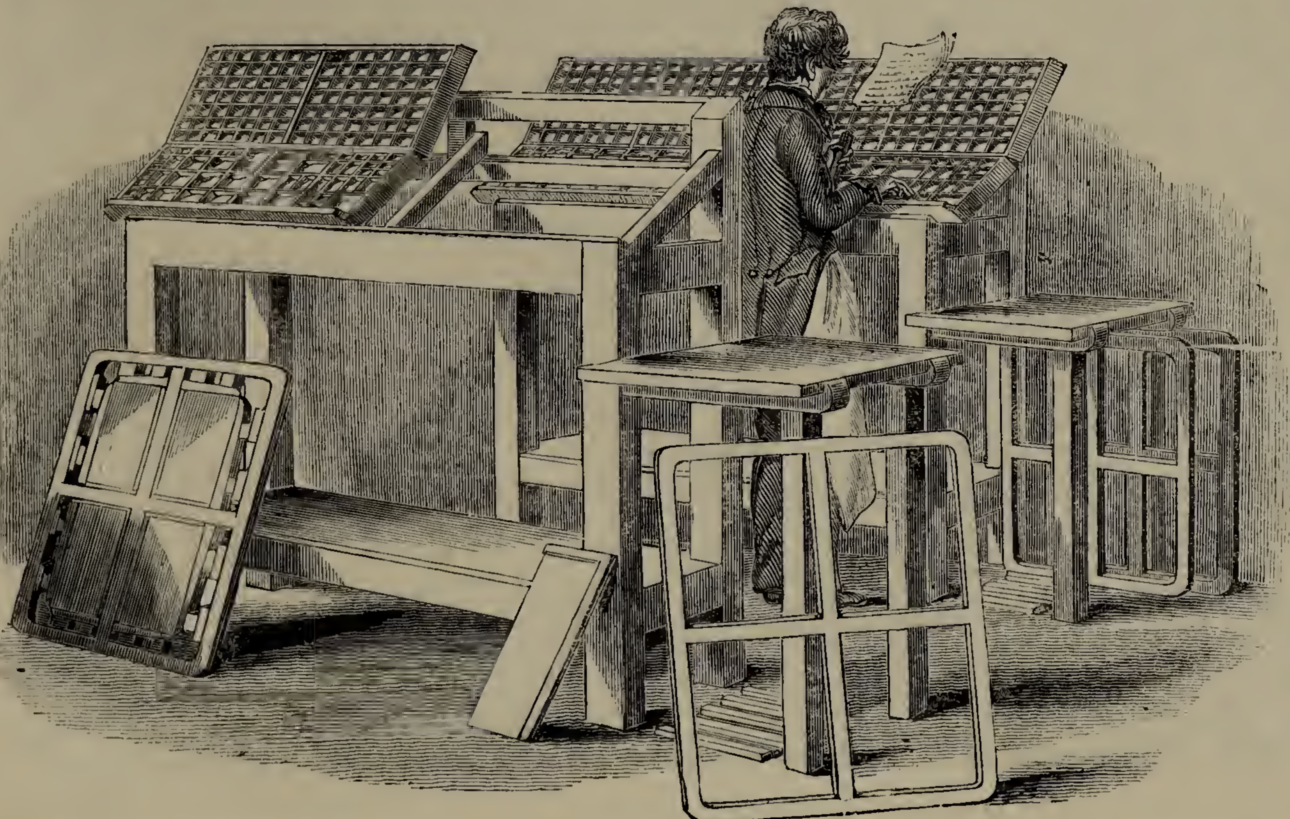
1413.—Stereotype Moulding-frame.

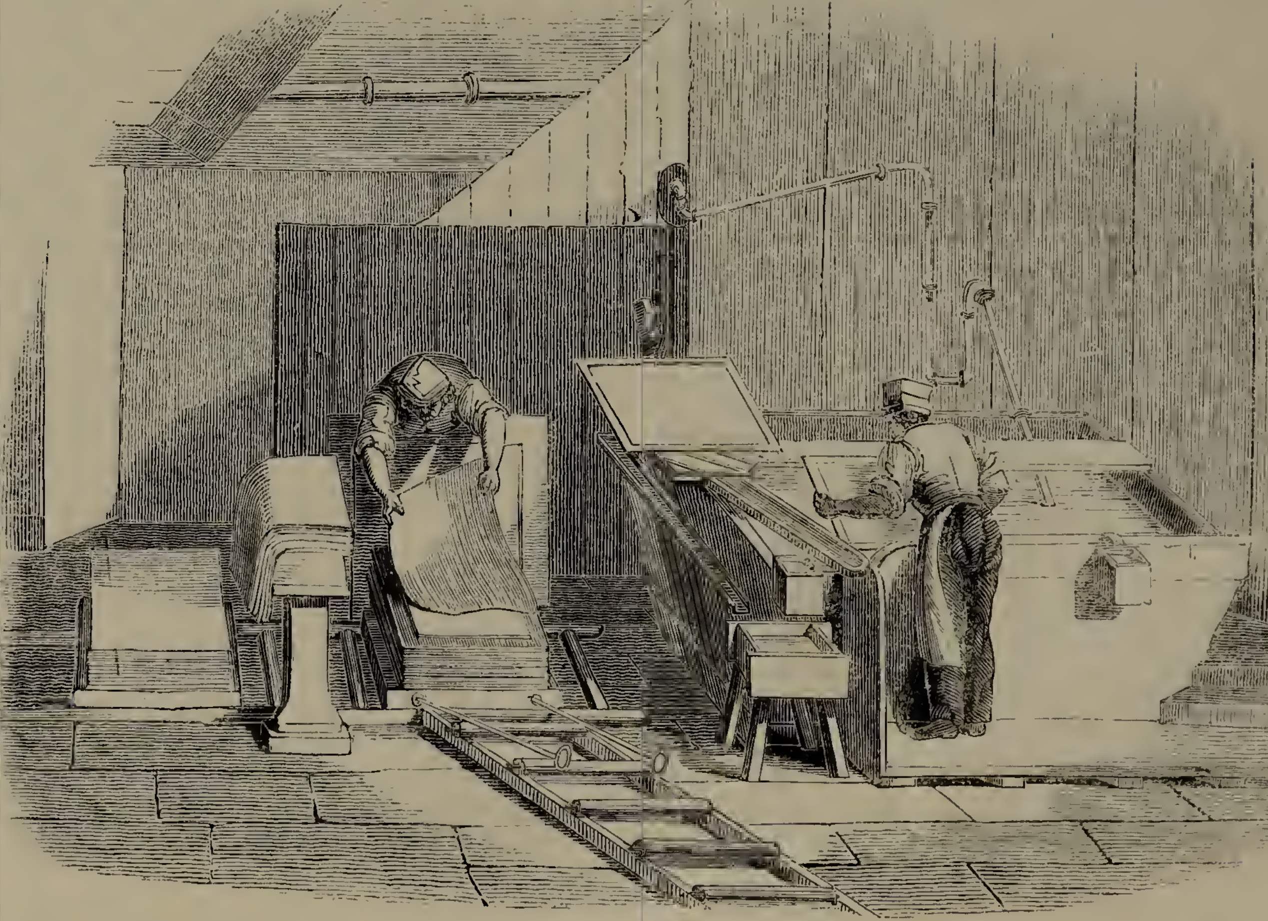


1414.—Paper-cutting Machine.



1415.—Type-Founding.





1417.—Paper-making: by Hand.

There is a kind of isinglass wafer prepared by the French in the following way:—A solution of isinglass in water is prepared, and is poured upon a glass plate which is provided with a raised border: the isinglass is coloured by any of the usual pigments before being poured on the plate; and the plate itself is moistened with something which will prevent the adhesion of the isinglass. When the thin film has solidified, it is separated from the plate, and cut up into wafers in the same way as the commoner kinds. The wafers thus prepared are exceedingly thin, and more adhesive than those made of paste.—The Penny Postage system has led to the adoption of many kinds of "initial" and other wafers, displaying considerable ingenuity.

THE VARIETIES AND PROCESSES OF PRINTING.

We now approach that most important department of industrial art—*Printing*, one to which the world owes a debt of gratitude not easily estimated. It will not be an inappropriate opening to this subject to speak of the contrivances for Teaching the Blind to read, since these have in some instances included a rude kind of printing.

Substitutes for Printing: Printing for the Blind.

The main circumstance which led, nearly four centuries ago, to the invention of printing, was the great slowness with which books were necessarily prepared on the manuscript system. The tedious labours of the transcribers, even if remunerated at a very low rate, rendered the expense of each copy very great, and the diffusion of books was thus of necessity very much limited.

The cause of this slowness was evidently due to the fact that only one word could be committed to paper at a time, the writing being wholly dependent for its rapidity on the movement of the writer's fingers. Even if types had been invented they would not have been of use without being combined together in a group, and subjected to the action of some kind of press; for if each type were taken up separately, inked separately, and separately impressed upon the paper, it is easy to see that the process, instead of being quicker than that of writing with a pen, would have been slower. It is necessary, therefore, in considering the early history of printing, to bear in mind that the invention of types was only one stage in the matter—a stage which would have been of little avail if unaccompanied by other improvements. What these other improvements were we shall discuss presently. Previously, however, to doing so there are a few points relating to "blind-printing" which illustrate some of the circumstances under which types are capable of being used.

As any books intended for the blind must be so constructed as to enable the scholars to *feel* the letters, ordinary printing becomes unavailable, since the projection of the ink above the surface of the paper is too slight to be perceptible by the fingers, unless the letters be very large. Hence the ingenuity of many persons has been directed to the construction of plans which shall not come so much under the designation of printing as of substitutes for printing; for it is only one of the recent contrivances that embraces actual printing for the blind.

In an article on this subject in the 'Penny Cyclopædia,' after speaking of other contrivances for enabling the blind to read, it is stated that "Moveable letters were afterwards invented, which were placed on small tablets of wood, and were made to slide in grooves, on a similar plan to some of the toys which are made for the purpose of inducing children to learn their letters, spelling, &c. It was with similar letters that Usher, Archbishop of Armagh, was taught by his two aunts, who were both blind. But this process was found defective for teaching blind persons. Moveable leaden characters were afterwards cast for the use of the blind by Pierre Moreau, a notary of Paris; but the work was attended with difficulties and expenses which he was not prepared to encounter. Large pincushions were also brought into use for the blind, on which the characters were figured with inverted needles; perhaps the relief caused by the heads of pins would have been more eligible. Various other attempts were made in wood and metal till the time of Haüy, who invented the art of printing in relief for the blind. The latest improvements in this art are Mr. Gall's of Edinburgh, whose triangular alphabet, when printed in strong relief, can be rapidly read by persons whose tactile powers are less delicate than those commonly possessed by the blind. We give the shape of this alphabet (Fig. 1386), and regret we cannot show the relief; but we think we may assert that it is superior to every invention of this kind which has yet been produced, and deserving of every encouragement till it is proved by experience either that alphabetical characters are needless for the blind, or that stenography, or some other art yet to be discovered, offers greater advantages."

There is a Blind Asylum at Glasgow in which the use of raised letters has been carried out on a very extensive scale, chiefly through the indefatigable perseverance of a gentleman who fills the office of treasurer. There have been, in the first instance, letters or types formed of a metallic alloy something like that of which common printing types are made. These types are in the English character, and consist of capital letters and numerals, from a quarter of an inch high to others of larger size. The letters have no alternation of thick and thin lines, but are uniformly thin, to form an impression better on the paper. No ink is used in printing from these types, but the types are put up into forms, and then pressed forcibly down upon a sheet of damp paper by means of a press; the force exerted makes the types leave a deep indentation in the paper, but without cutting through it. The paper on the opposite surface then presents a series of projections wherever the types had pressed, and these projections are sufficient to be detected by the sensitive fingers of the blind. There is thus a difference between such printing and that ordinarily adopted for those readers who can see their book: the latter read on the surface which is printed, whereas the former read on the opposite page. At the Glasgow Asylum the entire Bible has been printed in this manner, at a press kept in the Asylum, the whole occupying twelve or fourteen large volumes, since, as the letters are very large, only a small quantity of words can be got into a page. A number of minor works have been prepared in a similar manner. It is surprising to a spectator to observe the readiness with which the blind students read books prepared in this way; for, although the letters are certainly raised above the general level of the paper, the elevation is so slight as scarcely to be perceptible by the fingers of an ordinary person, and yet the blind can detect all the letters of a word by passing the finger slightly and delicately over them.

A very curious kind of "String-Alphabet" (Fig. 1392) was devised a few years ago by two inmates of the Edinburgh Blind Asylum—a teacher named David Macbeath, and a scholar named Robert Mylne. Their own description of the contrivance is as follows:—The string-alphabet is formed by so knotting a cord that the protuberances made upon it may be qualified, by their shape, size, and situation, for signifying the elements of language. The letters of this alphabet are distributed into seven classes, which are distinguished by certain knots, or other marks. Each class comprehends four letters, except the last, which comprehends but two. The first, or A class, is distinguished by a large round knot; the second, or E class, by a knot projecting from the line; the third, or I class, by the series of links vulgarly called the "drummer's plait;" the fourth, or M class, by a simple noose; the fifth, or Q class, by a noose with a line drawn through it; the sixth, or U class, by a noose with a net-knot cast on it: and the seventh, or Y class, by a twisted noose. The first letter of each class is denoted by the simple characteristic of its respective class; the second by the characteristic and a common knot close to it; the third by the characteristic and a common knot half an inch from it; and the fourth by the characteristic and a common knot an inch from it. Thus, A is simply a large round knot; B is a large round knot, with a common knot close to it; C is a large round knot, with a common knot half an inch from it; and D is a large round knot, with a common knot an inch from it; and so on. The knotted string is wound round a vertical frame, which revolves, and passes from the reader as he proceeds.

Of the general character of this string-alphabet the inventors say:—"It must readily occur to every one that the employment of an alphabet, composed in the manner which has been explained, will ever be necessarily tedious; but it should be borne in mind that there is no supposable system of tangible figures significant of thought that is not, more or less, liable to the same objection. . . . . . There can scarcely be any system of tangible signs which it would be less difficult either to learn or to remember, since a person of ordinary intellect may easily acquire a thorough knowledge of the string-alphabet in an hour, and retain it for ever. Yet the inventors can assure their readers that it is impossible for the pen or the press to convey ideas with greater precision. Besides the highly important properties of simplicity and accuracy which their scheme unites, and in which it has not been surpassed, it possesses various minor, nor yet inconsiderable advantages, in which it is presumed it cannot be equalled by anything of its kind. For example; its tactile representations of articulate sounds are easily portable—the materials of which they are constructed may always be procured at a trifling expense—and the apparatus necessary for their construction is extremely simple. In addition to the letters of the alphabet, there have been contrived arithmetical figures, which it is hoped will be of great utility, as the remembrance of numbers is often found peculiarly difficult. Palpable commas, semicolons, &c., have likewise been provided to be used, when judged requisite."

Various other contrivances, bearing more or less on this point, have been brought into use from time to time; but they do not relate sufficiently to the subject of printing to call for notice here. An "Arithmetical Board" for the use of the blind will be described in the next chapter.

Early Printing in Germany: John Gutenberg.

Those parts of the above details which relate to actual *printing* for the blind, will have given an insight into one of the most notable stages in the establishment of printing, as an art generally; viz., the substitution of *moveable* types for *fixed* ones. But the relation which this bears to the other stages requires a little further elucidation.

Let us take a written manuscript as the starting point, and see how the advance was made from ancient transcribing to modern printing. A large wooden block, the size of one page of a book, might be carefully prepared at the surface, and engraved all over with words and sentences: the letters being left prominent, and all the rest of the surface being cut away. If, then, this carved surface were carefully inked, and then pressed down upon a sheet of paper, a copy of the inking would be transferred; and if the words had been carved in a reversed position, or hindside before, they would appear in the proper position on the paper. Thus a great saving of time would occur, inasmuch as the whole of one page full of writing could be transferred to the paper at once. But on the other hand, a slow and costly process would be necessary in preparing the blocks; since each block would be fitted only for one page, and could not be so dissected as to make it applicable to another. This would lead to the suggestion of cutting up the block into a number of little pieces, each of which should contain only one letter; and if the letters were all nicely squared at the sides, and all of equal thickness or height, they might be laid side by side in any desired order, like a set of dominoes; and, being well secured in their places, they might be inked and employed in printing just the same as a large block. When the printing was effected, the small letters might be separated one from another, and grouped up again in another order; so that the very same small pieces of wood which had been employed to print a Bible might be afterwards available for printing a work relating to science or history, or any other branch of knowledge. This would be a notable advance; but another one would suggest itself in the course of time. If there were several copies of one letter wanted (which is sure to occur even in a short sentence) there would be entailed the necessity of carving as many little bits of wood separately as there were multiples of the letter required. Under such circumstances, the analogy furnished by many other branches of art would lead to the adoption of a process of *casting;* whereby, after a mould had been once prepared, an unlimited number of copies could be obtained, by the use either of some metal which melts easily, or of some other material fitted for the process of moulding.

Now these successive steps which we have been supposing, were precisely those which the early history of printing presented. Shortly after the commencement of the fifteenth century, there was a custom practised—though it is still a disputed point whether the invention of it was due to Europe or to Asia—of engraving a rude kind of pictures on blocks of wood, and taking impressions of them on some coarse kinds of paper. This led to the art of type-printing, though the inventors most probably did not anticipate such a result. It is a curious circumstance that these pictures related to two remotely opposite classes of subjects; viz., *Religious works*, and *Playing Cards*. The misshapen knaves and queens and kings of modern playing cards have worked a more important service than card-players usually imagine; they are slightly altered copies of the devices printed on the playing cards which are known to have been in use four centuries ago; and those rude devices were among the elements out of which the art of printing arose. The religious works consisted of portraits of saints, Scriptural events, and monkish legends; all of the rudest possible style of execution. The collection of Earl Spencer contains a print representing St. Christopher carrying the infant Saviour: this print has the date 1423, and it is the earliest authentic one now known to have been produced from a wood block.

If these rudely-carved blocks had only contained pictures, the relation which they bear to type-printing would not be obvious; but the scriptural pictures were often accompanied by a few sentences from the Bible, which sentences were cut in the block in the same way as the pictures. Hence, if it were possible to cut a few sentences as an auxiliary to a picture, it would be equally possible to carve the whole of the block in this way, and have no picture at all. Such was done by degrees. A selection of texts from the Scriptures was cut upon blocks, and a work published under the title of 'Biblia Pauperum,' or the Bible of the Poor. This was followed by another work, the 'Speculum Salutis,' or Mirror of Salvation. Several manuals of grammar, and other works, were engraved and printed in a similar way.

It is hopeless to expect that the name of the inventor of the above method should ever be discovered; for, from its nature, it is susceptible of such imperceptible gradations, that it is scarcely possible to say where the wood-block *picture* merged into the wood-block *type*. The inventor of the next important improvement, however, is generally allowed to have been John Gutenberg of Mayence. At one time there was a great deal of discussion as to whether Gutenberg, Faust, Coster, or Schœffer, was the inventor of moveable types for printing; but the investigations of the last few years have led to a pretty general opinion, that all had a hand in the matter, and are all therefore worthy of our respect and gratitude, but that Gutenberg seems to be the man worthy of the designation of "inventor of printing by moveable types." Schœffer appears to have improved upon this idea by substituting cast metal types for carved wooden ones; while Faust encouraged and assisted both of them with his capital and support. From that time the art of printing was to all intents and purposes established; for, let the cast types have been as rude as they might, they possessed practically all the chief excellences of those in the present day.

In the month of August, 1837, honour was done to the memory of Gutenberg by the erection at Mayence of a beautiful statue by Thorwaldsen, the Danish sculptor. The statue was the result of a subscription, to which all the principal states of Europe were invited to contribute, but to which (strange as it may seem) England contributed little or nothing. Mr. Knight, in his Life of Caxton ('Weekly Volume,' No. 1), speaking of the memorable 14th of August in that year, says:—"The fine statue of Guttenberg" (Gutenberg, Guttenberg, Gutenberger, Guttenberger—all these modes of spelling the name are occasionally adopted) "was opened amidst an universal burst of enthusiasm. Never were the shouts of a vast multitude raised on a more elevating occasion; never were the triumphs of intellect celebrated with greater fervour. The statue of Guttenberg, who had won for his city the gratitude of the world, was opened with demonstrations of popular feeling, such as have been wont only to greet the car of the conqueror. The poor printer of Mentz, indeed, achieved a conquest; the fruits of his bloodless victory are imperishable: but it is honourable beyond comparison to the present generation of the citizens of Mentz to have felt that this victory of mind, which has made all future victories of the same nature permanent, was deserving of a trophy as enduring almost as the invention which it celebrates" (p. 70).

This statue is a very fine specimen of Thorwaldsen's skill. Gutenberg is represented (Fig. 1396) in a standing position, holding in one hand a book, and in the other a few moveable types. On the pedestal on which he stands are two sculptures in bas-relief; one of these (Fig. 1397) represents Gutenberg examining a matrix, from which the moveable types are to be prepared; while in the other (Fig. 1397) he is shown as employed in comparing a printed sheet with a manuscript. Mr. Knight describes the ceremonies attendant on the inauguration of this statue thus:—"We never saw such a popular fervour as prevailed at Mentz at the festival of August, 1837. The statue was to be opened on Monday the 14th; but on the Sunday evening the name of Guttenberg was rife through all the streets. In the morning all Mentz was in motion by six o'clock, and at eight a procession was formed to the Cathedral, which, if it was not much more imposing than some of the processions of trades in London and other cities, was conducted with a quiet precision which evidenced that the people felt they were engaged in a solemn act. The fine old cathedral was crowded; the Bishop of Mentz performed high mass;—the first Bible printed by Guttenberg was displayed. What a field for reflection was here opened! The First Bible, in connexion with the imposing pageantries of Roman Catholicism—the Bible, in great part a sealed book to the body of the people; the service of God in a tongue unknown to the large number of worshippers; but that first Bible the germ of millions of Bibles that have spread the light of Christianity throughout all the habitable globe! The mass ended, the procession advanced to the adjacent square, where the statue was to be opened. Here was erected a vast amphitheatre, where, seated under their respective banners, were deputations from all the great cities of Europe. Amidst salvoes of artillery the veil was removed from the statue, and a hymn was sung by a thousand voices. Then came orations; then dinners—balls—oratorios—boat-races—processions by torch-light. For three days the population of Mentz was kept in a state of high excitement; and the echo of the excitement went through Germany,—and Guttenberg! Guttenberg! was toasted in many a bumper of Rhenish wine amidst this cordial and enthusiastic people."—(p. 82.)

Early Printing in England: William Caxton.

Such inventions as those due to Gutenberg and Schœffer could not long remain unknown in England. Although the turmoils of civil war had hardly ceased in this country, and men's minds were scarcely in a state of sufficient calm to attend to literature and its advancement, yet the facilities afforded by the invention of printing with moveable types were too great to remain overlooked. Germany, it is true, took the lead at that time in many departments of mechanical art. Whether it also took the lead in regard to popular education, it is not now easy to say; for popular education was at a sufficiently low ebb in all countries. But we know that at the present day the cultivation of the middle and humble classes is carried farther there than in England; and that works are sold and appreciated there by classes which would scarcely understand them here. Take the itinerant map-sellers, for instance (Fig. 1389), many of whom are to be seen about the streets of German towns: they can there find a sale for commodities which would be almost unsaleable under similar circumstances in England, because the love and knowledge of geography are more advanced in the former country than in England. Hence there may possibly have been reasons of a literary or educational nature why printing should have sprung up in Germany rather than in England.

Be this as it may, to William Caxton is due the merit of having printed the first book in England. Caxton is supposed to have been born about the year 1412. At the age of eighteen he was apprenticed to a mercer in the city of London: and he appears to have risen to a position of opulence and respectability. At a later period of life, having a considerable amount of leisure, he gave himself the task of translating into English a French work, Raoul le Fevre's 'Recueil des Histoires de Troye.' He travelled in Germany and the Netherlands, and appears during the course of his travels to have become acquainted with the then modern art of printing. He printed two or three works in Germany, and then brought the art to England. The exact dates when these events occurred are not now clearly known; but by the year 1477 he had taken up his residence in the Almonry at Westminster (Fig. 1394), where he carried on the occupation of a printer. His 'Game and Playe of the Chesse,' as well as two or three other works, were printed before this date; but the locality is an undetermined point.

Caxton was an industrious translator as well as printer: for he gave himself the trouble of translating into English many of the books which he afterwards printed. He spared no pains in obtaining correct copies of the works which he printed; and this was in many cases a difficult matter, for as all the books before that time were in manuscript, the process of copying with the pen was very likely to lead to variations in the subject matter of the book, arising out of the ignorance or the carelessness of the transcribers.

Caxton seems to have been exposed to a difficulty of this kind in respect to an edition which he printed of Chaucer's 'Canterbury Tales.' In a second edition of this work he thus spoke of the imperfections of the manuscript copies which had been alone available to him:—"Of which book so incorrect was one brought to me six years passed, which I supposed had been very true and correct, and according to the same I did imprint a certain number of them, which anon were sold to many and divers gentlemen; of whom one gentleman came to me, and said that this book was not according in many places unto the book that Geoffrey Chaucer had made. To whom I answered, that I had made it according to my copy, and by me was nothing added nor diminished. Then he said he knew a book which his father had, and much loved, that was very true, and according unto his own first book by him made; and said more, if I would imprint it again, he would get me the same book for a copy. How be it, he wist well his father would not gladly part from it; to whom I said, in case that he could get me such a book true and correct, that I would once endeavour me to imprint it again, for to satisfy the author; whereas before by ignorance I erred in hurting and defaming his book in divers places, in setting in some things that he never said nor made, and leaving out many things that he made which are requisite to be set in it. And thus we fell at accord; and he full gently got me of his father the said book, and delivered it to me, by which I have corrected my book."

Caxton appears to have employed five distinct "founts," or sets of type. The first of these, with which his earlier works were printed, was the sort called "Secretary," and of this he had two founts; afterwards he had three founts of "Great Primer;" and then others of "Double Pica" and "Long Primer,"—these being the names employed by printers to designate the kind of type employed by them.

A number of other printers soon followed Caxton's example, and printed books multiplied very rapidly. Each printer, having a sort of pride in the excellence of his own workmanship, adopted a "mark," or symbol, which generally comprised a small but rude wood-cut, together with certain initials or inscriptions. Thus, some of these, in relation to Caxton, are included in the various component parts of Fig. 1400. In the middle is a portrait of Caxton himself; above this is a view in the Weald of Kent, where he was born; and below it is the old Hall of the Mercers' Company, of which he was a member; on the left side is Westminster Abbey, and on the right the Almonry; while the other figures comprise two initial letters employed by him in printing, a monogram which formed his device, and certain paper-marks which he adopted. The six cuts (Figs. 1401 to 1403, and 1405 to 1407) represent the marks of six of the early printers, which are certainly curious specimens of wood-cut engraving. Wynkyn de Worde was a friend and assistant of Caxton; and from his press, from 1493 to 1535, appeared no fewer than four hundred books; he was proud of his former connexion with his old master, and always included Caxton's initials in his own "mark." Richard Pynson is supposed to have been another of Caxton's assistants: he was a native of Normandy, but carried on the business of a printer in England during a period about as long as De Worde's career; he obtained a small salary as "King's printer," being the first person who occupied that station. All the other printers whose marks are given in the cuts alluded to, lived in England about, or soon after, the end of the fifteenth and the beginning of the sixteenth centuries; since which time the art of printing has advanced with a rapidity which it would be useless to attempt to follow.

In those early times, before the division of employments was well understood, the printer used to make his own types and his own ink, and the labours of a printing office were more heterogeneous than they now are. In an old Dutch print (of which a copy is given in Fig. 1395) the compositor's work, the reading and revising, and the press-work, are all done in the same room. It is stated that, about the time when Caxton commenced operations in England, a printer named Melchior de Stamham, wishing to establish a printing office at Augsburg, engaged a skilful workman, and proceeded to make the necessary arrangements and purchases, which occupied him a whole year. He bought five old wine-presses and made them up into printing-presses; he cast pewter types, and made many other preparations; but the expense was so great that he ruined himself, and died broken-hearted. Not unfrequently a printer had to be his own press-maker, type-founder, ink-maker, and book-binder: and hence it may easily be supposed that a printer was in such days regarded as a very important personage.

Type-Founding: Compositors' Work.

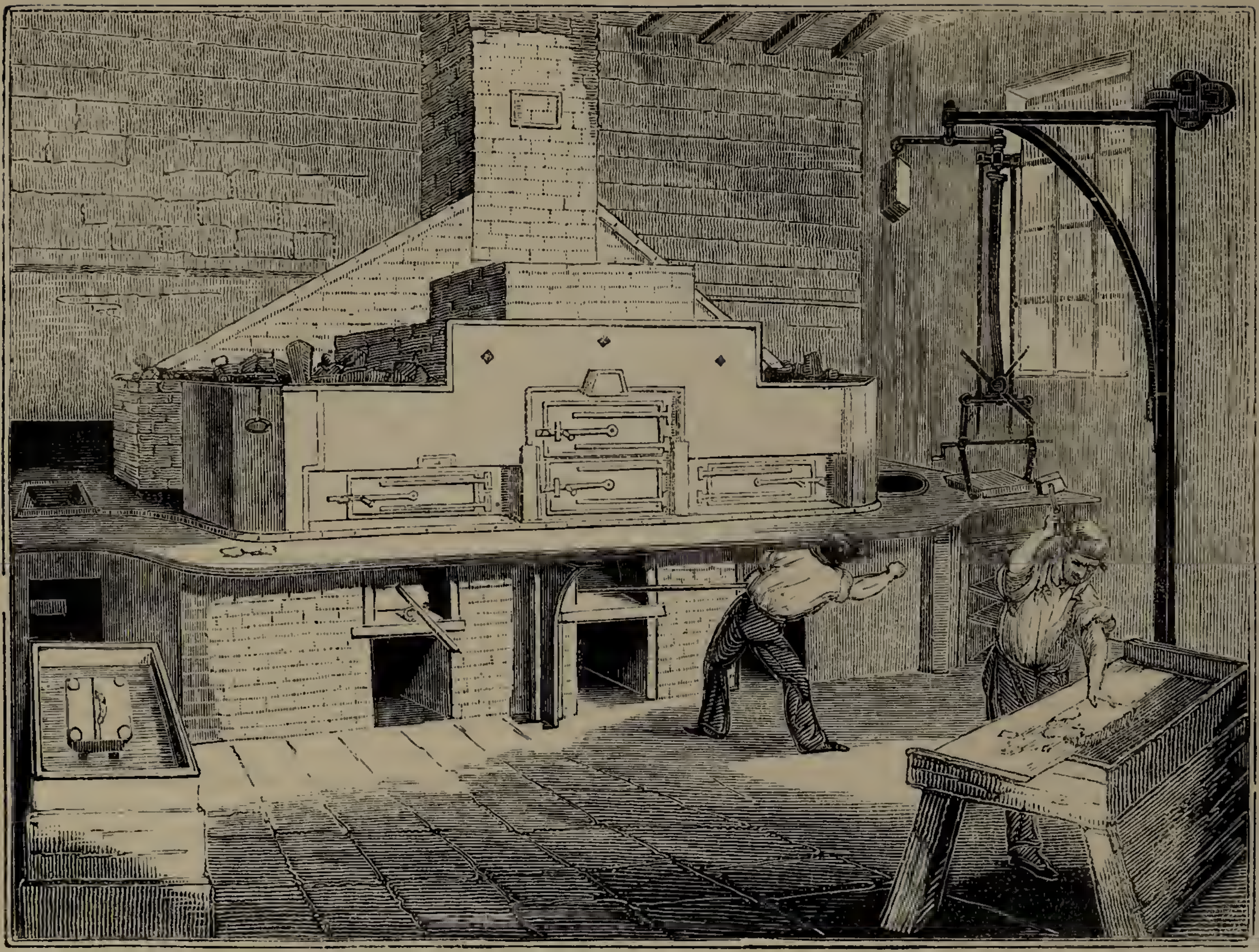
The above details will furnish an idea of the kind of links which bind together the different parts of the operations connected with printing. From these it will be obvious, that the first process connected with the matter is the making of the types which are to represent written characters; and that the second is the setting up of these types into such groups as will form the pages of a book. To these departments of the printer's art we will at once proceed. The date of the reputation of English types is from the time of William Caslon, who made a fount of Arabic type in the year 1720, the excellence of which gave to this branch of art a much higher tone than had before belonged to it.

Printing-types are made of a mixture or alloy of lead and antimony. The early printers were a good deal perplexed to determine the proper materials for types, since the metal ought to melt easily, and yet be hard when cold. The above two metals are now found to be fitted for the purpose: there are from three to five parts of lead to one of antimony, according to the size of the types, the smallest requiring the most antimony in order to make them harder. The type-founders have an immense variety of moulds for casting type—Roman, Italics, old English, Greek, capitals, and small letters—very minute "Diamond" and very large "Double Pica"—numerals and stops, &c., in order to meet the requirements of the several kinds of printing. The largest type commonly employed in printing a book is that called "Double Pica," of which $41\frac{1}{2}$ lines go to a foot; while the smallest is "Diamond," with 205 lines to a foot. The range of sizes (all of one character of type) embraces thirteen kinds, which are designated in the following odd way, and occupy the following number of lines to the foot:—

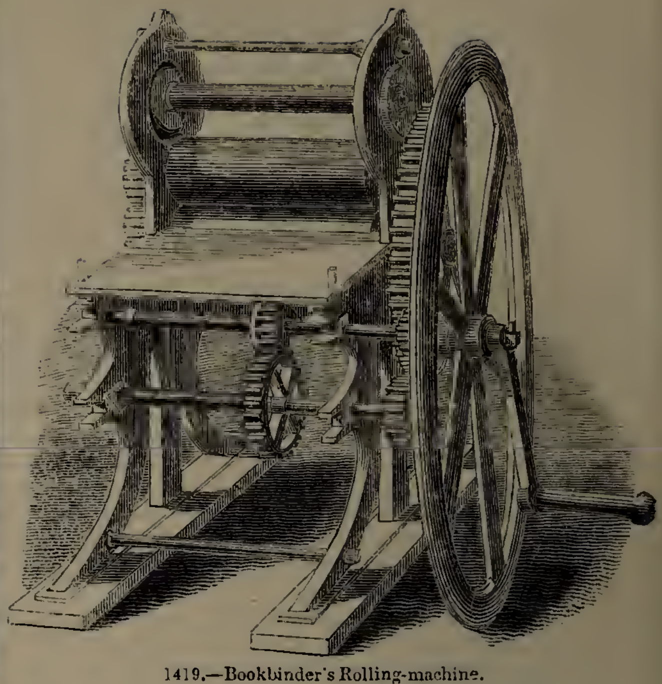
Double Pica	$41\frac{1}{2}$	Bourgeois	$102\frac{1}{2}$
Paragon	$44\frac{1}{2}$	Brevier	$112\frac{1}{4}$
Great Primer	$51\frac{1}{2}$	Minion	128
English	64	Nonpareil	143
Pica	$71\frac{1}{2}$	Pearl	178
Small Pica	83	Diamond	205
Long Primer	89		

Many of these names originated from the titles of books which were customarily printed with the types in question; but the smallest, which are probably of modern origin, seem to have been named on another principle.

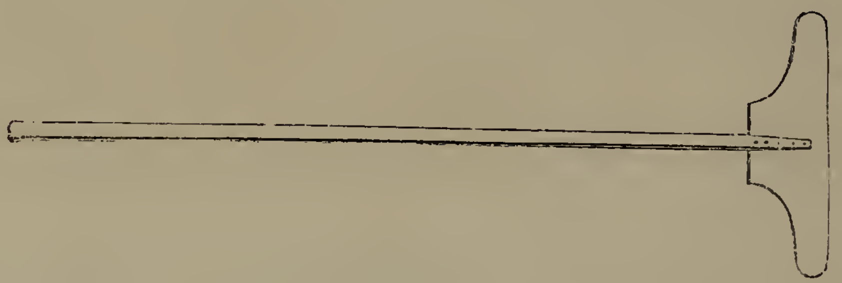
Perhaps specimens of types, as here given, will convey a better notion of them than the relative number of lines to a foot:—



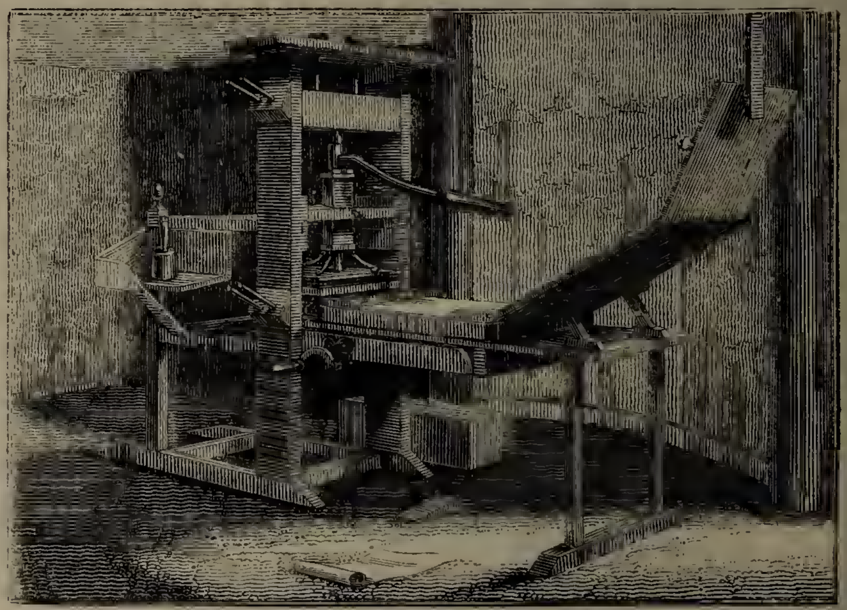
1418.—Stereotype Foundry



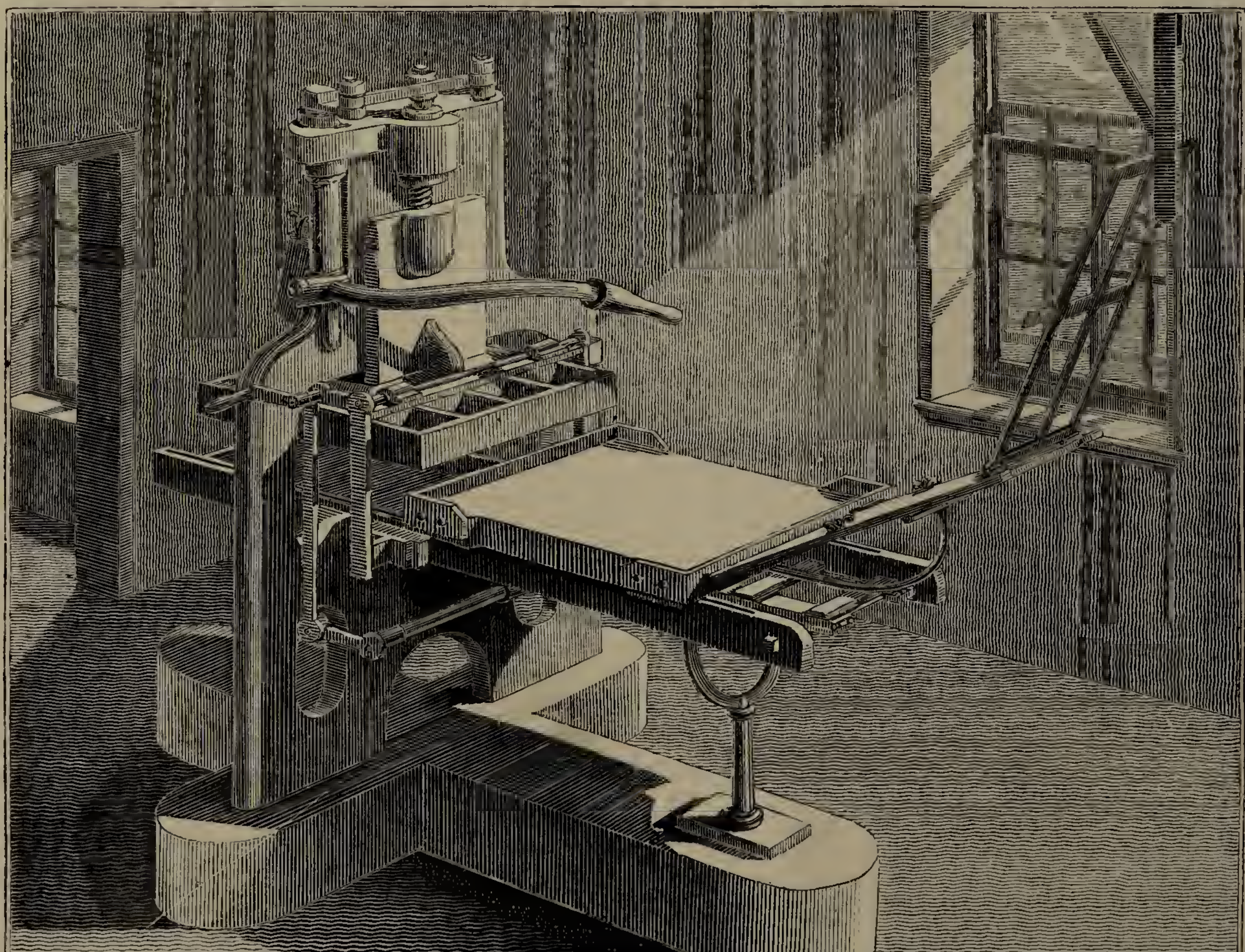
1419.—Bookbinder's Rolling-machine.



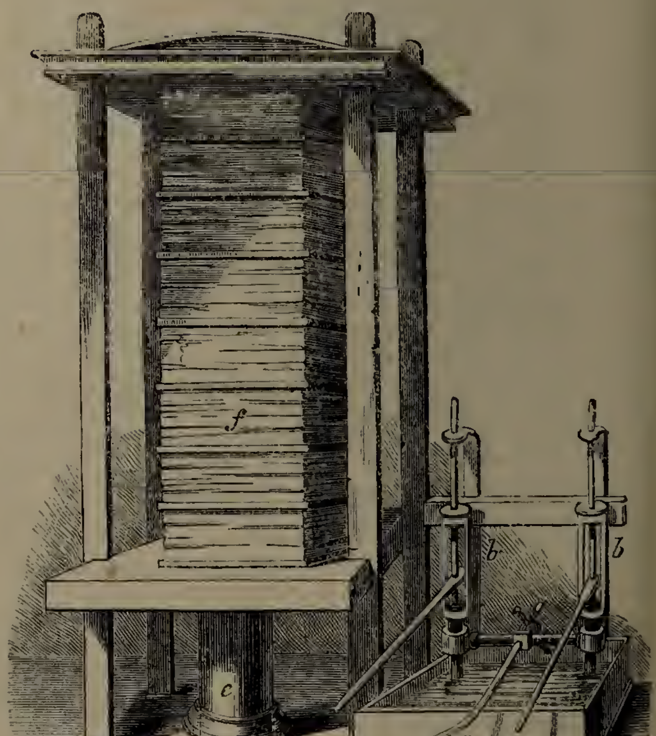
1420.—Printers' "Peel."



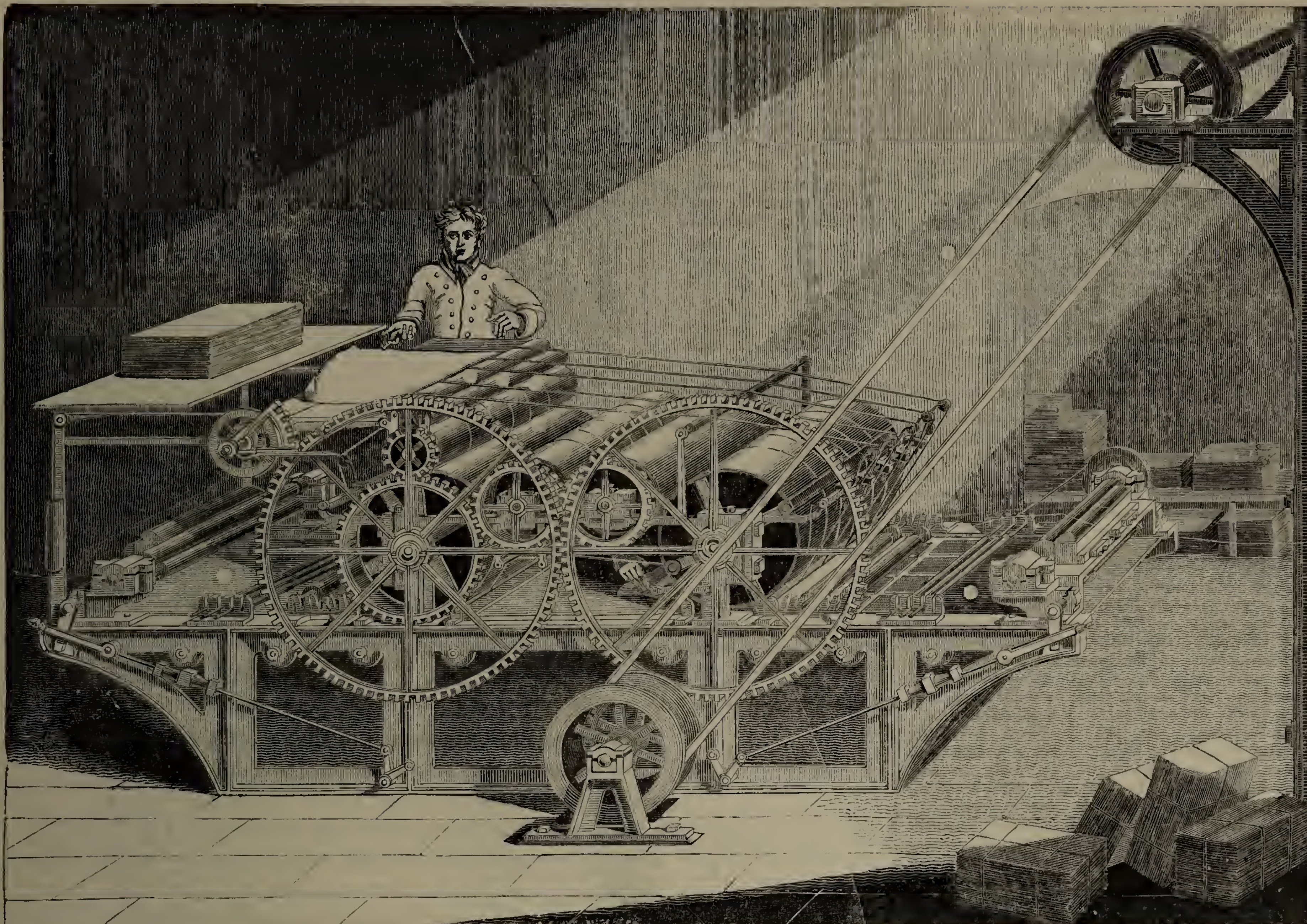
1421.—Common Printing-press.



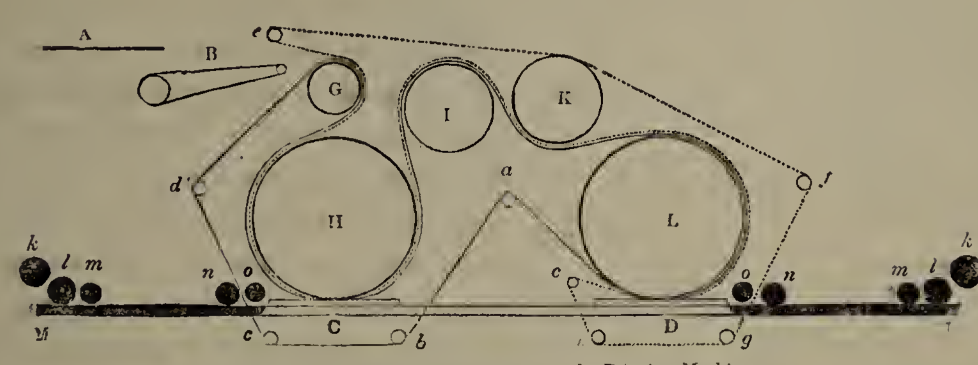
1422.—Stanhope Press.



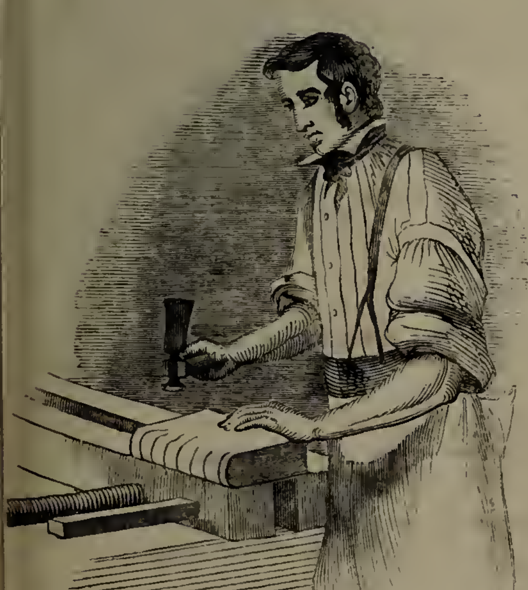
1423.—Printed Sheets in the Hydraulic Press.



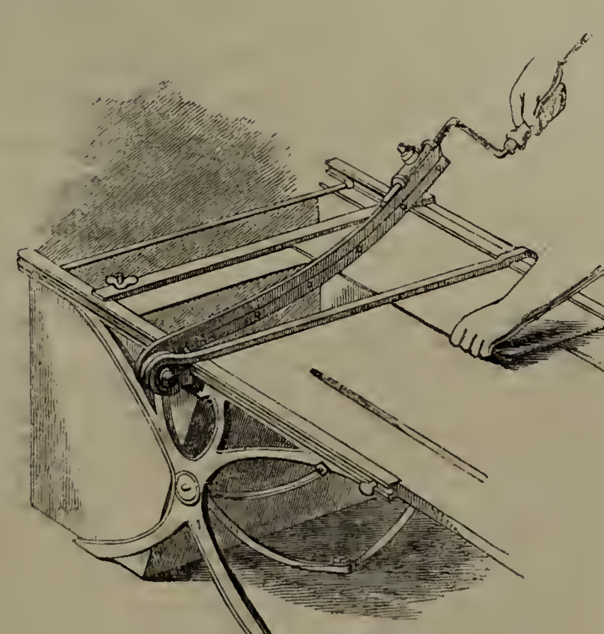
1424.—Printing-Machine.



1425.—Diagram to show the Action of the Printing-Machine.



1426.—Rounding the Back of a Book.



1427.—Bookbinders' Board-cutting Machine.

1428.—Sewing-Press.

Names of the various sized Types.	Specimens of the various sized Types.
Double Pica .	The art of prin
Great Primer .	The art of printing
English . . .	The art of printing inv
Pica	The art of printing invent
Small Pica . .	The art of printing invented i
Long Primer .	The art of printing invented in G
Bourgeois . .	The art of printing invented in Ger
Brevier . . .	The art of printing invented in German
Minion . . .	The art of printing invented in Germany
Nonpareil . .	The art of printing invented in Germany in 14
Ruby . . .	The art of printing invented in Germany in 1440
Pearl . . .	The art of printing invented in Germany in 1440 by Joh
Diamond . .	The art of Printing invented in Germany in 1440 by John Gutte

In making the types, a "punch," a "matrix," and a "mould" are successively employed. The punch is a rod of hardened steel, having a letter at one end, formed by hammering down the depressed portions when the metal was in a soft state. This punch is employed to make an impression in the matrix, which is a piece of copper about an inch and a quarter long by an eighth of an inch in width, and deep in proportion to the size of the letter to be made. The mould (Fig. 1404) is an ingenious little apparatus, composed of two halves, which are held together by a spring, so that the internal cavity thus formed shall serve as a mould for casting; and the matrix is adjusted in it.

The mould being thus formed, the type-metal is prepared at a small furnace (such as at the right hand of Fig. 1415). The mixed metal is melted in a pot; and the workman, holding the mould in his left hand, takes up a little of the melted metal in a very small spoon or ladle, and pours it into the mould. As soon as the mould is filled, the workman gives a sudden jerk with his hand, by which the metal is forced into all the little cavities and depressions of the mould; then, loosening the spring by which the two halves of the mould are held together, he opens the mould sufficiently to remove the cast letter from it; he next closes the mould again, and proceeds just as before, lading in with the little spoon enough to fill the mould time after time. When it is considered that the cavity of the mould, and consequently the size of the type which can be cast in it, is only about an inch long, an eighth of an inch wide, and generally much less than that in thickness, it may be supposed that the quantity of metal poured in at once is very minute. But this is not the most remarkable part of the operation; for the celerity with which the type is made excites more surprise in a stranger than the small quantity of metal cast at once. The type-founder closes the mould, dips the little spoon into the melted metal, fills the mould, jerks it above his head, opens it by means of the spring, and removes the cast type from it—all in one-eighth part of a minute, since he repeats this series of operations five hundred times in an hour!

When the types are cast, they are cleansed from the superfluous metal, and rubbed on the two opposite sides to make them flat and smooth. They are next set up on end, face downwards, and a plane is run over them, to ensure all the types being exactly of the same length—a point essential to the proper arrangement of them for printing. These operations are shown in Fig. 1415. The types are then formed into "founts" or sets, and delivered to the compositor.

The compositor, whose labours consist in setting up the several letters in the proper order for printing, is provided with an apparatus called a "frame." This frame (Fig. 1412) is a sort of desk, in front of which the compositor stands while at work. The frame contains two pairs of "cases," one pair for Roman letters, and one for Italics. Each case contains a great number of divisions or compartments for the several letters of the alphabet. The upper case of each pair contains compartments for the capital letters, the numerals, the accented vowels, and the marks of reference for notes; while the lower case of each pair contains the small letters, the stops, and the spaces which are to be placed between the words. The compartments are very numerous, and are planned, with respect both to their sizes and their relative positions in the case, with singular ingenuity. Those letters which are required most frequently in printing are placed nearest to the hand of the compositor, and are kept in compartments larger than the others. The compartments do not follow the order of the alphabet in their general classification, and thus appear to a looker-on to be very confused and badly arranged; but there is a reason for every feature of the arrangement, ascertained by long experience. In filling his cases with type, previous to setting to work, the compositor finds it necessary to put more than an average quantity of those which are required most, and it is necessary to appeal to experience as to which letters are so circumstanced. Accordingly, the general character of each language becomes so well known, in this respect, to the type-founder and the compositor, that the relative quantities of all the different letters required have been determined very exactly. Thus, in Latin and French words there are more of the *c*, *i*, *l*, *m*, *p*, *q*, *s*, *u*, and *v* than in English. In the English language the *e* occurs more frequently than any other letter. A "fount," or set of small letters for printing, contains twelve thousand *e*'s, and the whole alphabet requires the following proportions:—

a	8500	h	6400	o	8000	v	1200
b	1600	i	8000	p	1700	w	2000
c	3000	j	400	q	500	x	400
d	4400	k	800	r	6200	y	2000
e	12000	l	4000	s	8000	z	200
f	2500	m	3000	t	9000		
g	1700	n	8000	u	3400		

With respect to the use of *Capitals* in printing, Benjamin Franklin, who had been a printer, made the following remarks in one of his Letters:—"In examining the English books that were printed between the Restoration and the accession of George II., we may observe that all substantives were begun with a capital, in which we imitated our mother-tongue, the German. This was more particularly useful to those who were not well acquainted with the English, there being such a prodigious number of our words that are both verbs and substantives, and spelt in the same manner, though often accented different in pronunciation. This method has, by the fancy of printers, of late years been entirely laid aside, from an idea that suppressing the capitals shows the character to greater advantage—those letters, prominent above the line, disturbing its even regular appearance. The effect of this change is so considerable, that a learned man of France who used to read our books, though not perfectly acquainted with our language, in conversation with me on the subject of our authors, attributed the greater obscurity he found in our modern books, compared with those of the period above mentioned, to a change of style for the worse in our writers; of which mistake I convinced him, by marking for him each substantive with a capital in a paragraph, which he then easily understood, though before he could not comprehend it. This shows the inconvenience of that pretended improvement." The custom which Franklin thus condemns is certainly not less prevalent now than it was when he wrote.

The compositor holds in his left hand a small piece of apparatus called a "composing-stick" (Fig. 1409). This is a metal frame with one side moveable, so that it may be adjusted to the required width of the column or page about to be printed. It will contain about ten or twelve lines of average type. The manuscript from which the printing is to be copied being placed open before the compositor, he reads a line or two of it; and, retaining the words in his memory, proceeds to pick up the letters one by one which will form the words, adjusting them in their proper order in the composing-stick, and placing the spaces which are to divide the words one from another. The rapidity and accuracy with which this is done are quite remarkable, and evince the tact which is obtainable by long practice. He places letter after letter, and word after word, until he has reached the end of his composing-stick; he then begins a new line, and proceeds on the same way until the stick is filled. He then grasps the whole of the letters in his fingers so dexterously as not to allow one to fall, and transfers them to a flat plate called a "galley."

The work of the compositor proceeds until he has as many lines set up as will fill a sheet; and he arranges his lines in the proper way one beneath an-

Example of the Modes of Correcting a Printed Proof.

1 c/ The prceess of printing, when eompared with that of
writing, is unquestionably a ~~dear~~ process; provided a 2 cheap
3 copies of suffieient number of any partieular bookare printed, so 4 #
5 ɔ as to renper the pro portion of the first expense upon a 6 ◠
7 ꝺ/ singgle eopy ineonsiderable. If, for example, it were
required, even at the present ~~moment~~ time, to print a 8 ꝺ/
single eopy, or even three eopies or four, only of any 9 tr
produetion, the cost of printing would be greater than
10 run on the eost of transeribing.
It is when hundreds. and especially thousands, of the 11 ,/
same work are demanded that the great value of the
12 tr/ printing press in maknig knowledge cheap, is par-
ticularly shown. It is probable that the first printers 13 N.P.
did not take off more than two or three hundred, if so
14 ;/ many, of their works and, therefore, the earliest printed
books must have been still dear, on aceount of the
15 italic/ limited nnmber of their readers. Caxton, as it appears 16 l.c.
by a passage in one of his books, was a ~~cautious~~ printer; 17 stet/
and required something like an aSsurance that he should 18 w.f/
sell enough of any particular book to repay the cost of
19 ⊙/ producing it In his 'Legends of Saints,' he says, "I 20 s. caps
have submysed (submitted) myself to translate into
21 ‘/ English the Saints of Legend,' called 'Legenda aurea' 22 tr/
23 Caps/ in Latin; and William, Earl of Arundel, sent me a
25 worshipful gentleman, promising that my said lord
should, during my life, give and grant to me a yearly fee, 26 ×
that is to note, a buck in summer and a doe in winter 27 "/

24 desired me—and promised to take a reasonable quantity of them—and

1. Is the mark for changing the wrong letter in the word process.
2. To substitute one word for another.
3. and 24. The first is the method of marking a short insertion, the second of marking a long one.
4. To have a blank space put between the two words.
5. To turn a letter which has been placed upside down.
6. To close the word in which a space has been improperly left.
7. and 8. To take away (*dele*, blot out) a superfluous letter or word.
9. 12. and 22. Different marks for transposing the arrangement of letters, words, or sentences.
10. To have no fresh paragraph.
11. To substitute a comma for a full-point or period.
13. To commence a new paragraph.
14. 19. 21. and 27. To insert points and marks of quotation.
15. To have any particular part printed in Italic.
16. To have words or letters printed in 'lower case,' or small letters; Roman is always understood, unless otherwise directed.
17. To have a word remain, which has been accidentally or erroneously marked. *Stet* is the Latin for "let it stand"
18. Points out a letter which does not match with the others; a 'wrong fount.'
20. and 23. To have certain parts printed in small or full capitals.
25. To set straight whatever may stand crooked.
26. To remove the unnecessary black mark between the words, which arises from what should form the space not having been pushed down.

other. Sometimes the pages of the book are made up as far as the type will go, before the "proof" is sent to the author for his revision; while on other occasions the type is put together in long slips or columns, to be afterwards adjusted into pages when the revision has been effected. Before being sent to the author, however, the proof is "read" carefully at the printing-office; that is, one person reads the author's manuscript while another reads the printed sheet, to see that the two agree, and to make the necessary corrections where they do not. Where so many thousand letters, stops, lines, spaces, and marks have to be arranged separately, it is next to impossible for the compositor to avoid making some blunders; and the correction of these blunders is very tedious work, for each wrong letter has to be picked out separately, and a proper one put in its place: the omission of a word will often derange several lines, and the omission of a sentence will render necessary the entire re-construction of a page. As the compositor is paid nothing for these corrections (his labours being remunerated according to the quantity of *correct* type which he has set up), he has every reason for trying to be as accurate as possible in the first instance. In making the corrections on the sheet of paper the "reader" uses certain marks or symbols at the sides, which instruct the compositor as to the corrections which he has to make.

When the reader has performed his task the compositor corrects his work; another copy is printed, and this copy, designated the "proof," is sent to the author, who adds or curtails or alters just as he may think the necessity of the case requires. Some proof sheets are sent back by the author scarcely altered at all, while others are so completely cut up that the compositor has to do nearly all his work over again. As these corrections are not due to any fault on the part of the compositor, he is paid extra for them. Very often the changes made by the author are so numerous that the compositor falls into new blunders in this third stage of his task, and a new "reading" is necessary.

The general nature of the corrections to which the compositor has to attend may be illustrated by the example on the preceding page, in which almost every kind of mistake is purposely introduced.

When the corrections or changes made by the author have been attended to, the proof is read very carefully by an experienced person, with a view to the detection of any and every blunder that may still remain, however minute it may be. Yet, after every care, there frequently remain little inaccuracies, which go through the whole of the printed copies of the work: so difficult is it to ensure perfect accuracy in these matters.

Preparing for Press: Stereotyping.

When the corrections are finally completed, the proper book-form is given to the type (if it had not been done before). The compositor is provided with a number of pieces of-apparatus (Fig. 1416), by which he is enabled to wedge the types together so closely as to bear the action of the printing-press or machine. In the first instance, after he has transferred as much type from the "composing-stick" to the "galley" as will fill one page, the compositor binds this group round with a string. Then, when he has as many of these groups as will fill one side of a sheet of paper, he arranges them in proper order on a bench called the "imposing-stone;" he surrounds each page-full of type with pieces of wood called "furniture," in order to keep them at the proper distance apart. If there are sixteen pages in a sheet, as for *octavo*, there are eight on a side, and therefore eight are arranged together in this way; so that the number of pages thus collected depends on the size in which the book is printed. The whole of the pages, with the "furniture" between them, are then wedged tightly together in a stout iron frame called a "chase;" and this frame, with its contents fixed immoveably in it, constitutes a "form." Another "form" is built up in a similar way, containing the pages which are to print the other side of the sheet; so that the sheet of paper, after being printed by one of these "forms," may undergo a second printing by the other. As a proof of the care with which these operations must be conducted, it may be stated that a form sometimes contains a hundred thousand types and separate pieces of metal or wood, not one of which must shift from its place throughout the whole process of printing.

In common type printing, the form is carefully examined to see that all the letters are on one general level, and that the inking would not be stronger at one part than another; and after this the printing proceeds. But in modern times a great feature has been introduced, under the name of "*stereotyping*," by which the printing is not effected from the types themselves, but from a cast from those types.

Let us suppose, as an illustration of the object of the "stereotype" process, that a publisher is pretty sure of a sale of one thousand copies of a new work: that he is doubtful as to a greater number; but that a greater number is actually called for by the purchasers. He must proceed in one of three ways. In the first, he prints off only a thousand copies, and agrees with the printer that the "forms" of all the sheets shall remain standing, until it is found whether more copies are wanted; the publisher paying to the printer a sum of money equivalent to the loss of capital incurred by allowing the forms to remain idle. In the second method, when the thousand copies are sold, and a demand still continues, the publisher prepares a "second edition," for which he has to incur the expenditure of money and of time sufficient to re-compose and re-make the book, just as at first. In the third method, after the "form" of types has been finally corrected, a cast is taken from it, and the printing is conducted from this cast; so that the cast itself can be preserved, as a fund from whence future copies of the work may be printed as wanted; while the types in the form can be separated, to be applied to some other use. This constitutes the stereotype process, which is found to be very advantageous for periodical works having a large but at the same time a fluctuating and uncertain sale; since it gives a power to the publisher of adapting his arrangements to the demand at any particular time.

The process of stereotyping requires that a mould should be taken from each form of types, and that a cast should be made from the mould sufficiently true and clear to print from. Hence there is a double process of casting for each page contained in a book—a striking proof of the large amount of trouble willingly incurred to gain the object in view. The page of type is wedged up securely in an iron case, and the surface carefully examined to see that no dirt or other imperfection interferes with the correctness of the surface. The page, thus secured, is placed in a case called the "moulding-frame" (Fig. 1413); and if any wood-cuts are to be introduced, the blocks are placed in the moulding-frame with the type—for it is one of the indications of modern skill in this department of art, that stereotype casts are taken from wood-cuts as well as from types. A skeleton frame is placed over the page in the moulding-frame, to determine the thickness of the mould to be taken from it; and the types are rubbed over with a little oily composition, to prevent adhesion. The mould is made of plaster of Paris, which is mixed with water to a liquid state, and poured over the page: it soon solidifies, and, on being removed, it presents an exact mould of the page, every letter of the types and every line of the wood-engraving being copied in reverse with minute accuracy.

The mould requires a careful process of baking to remove every indication of moisture from the plaster; this baking is effected in ovens constructed for the purpose (Fig. 1418). When thoroughly dried, the mould is ready to have the stereotype cast taken from it. This cast is made of a mixed metal of antimony and lead, like printing types themselves; and the metal is melted in a copper containing about half a ton. In the casting process there is an iron vessel employed called the "casting-box" (Fig. 1410), which has at the bottom a moveable plate of cast-iron, called the "floating-plate." Upon this plate the mould is placed, face downwards; and the cover of the box is placed over the mould: there are holes in the corners of this cover to admit the melted metal; and the internal arrangements of the box are such as to allow the metal to come in contact with the surface of the plaster-mould. The box is dipped into the cauldron of melted metal, and in a few seconds all the vacant spaces within it are filled. It is removed from the cauldron, and when cold the superfluous metal is broken away with a mallet, so as to separate the stereotype cast from the plaster-mould and from the floating plate.

This cast is now an exact representative of the original page. The plaster-mould was a reverse, giving in intaglio or cavity all the parts which were raised or in relief in the page, and *vice versâ;* but the metal-cast reverses this again, so as to come back to the original form. The stereotype plate, before being printed from, undergoes a very careful examination. If any slight corrections or additions are required, parts of the plates are cut or filed away, and other parts put in; if any of the letters have become filled up by the plaster or the metal, they are opened and properly shaped by small sharp tools; and if any of the fine lines of the wood-cuts have become disfigured, they likewise are restored to the proper state.

Even after all this work, the pages of stereotype plates require much adjusting before they can be printed from. Although cast with every care, the back of the plate is somewhat rough and uneven, and this want of accuracy is removed by the action of a beautiful lathe, which takes off a thin film from the back of the plate, and reduces it to an exactly equal thickness in every part. It is then screwed down upon a carefully prepared wood block to make it exactly the same height as the printing types, with which it has sometimes to be used in common. The pages, when arranged in order for printing, may differ very slightly in thickness, or a minute difference may occur in different parts of the same plate, so that, although no part might actually escape the ink, some portions might appear more faint than others, and thus produce great disfigurement in the printing. It often occupies a man several hours in "making ready" a form of stereotype plates for the press; since he has to place bits of paper under the parts which are a little too low, and has to take impressions time after time to see how the adjustment is proceeding.

Printing by the Press.

At length our details have arrived at the point where the printer, properly so called, or the "pressman," commences his operations. The inking of the form of types, and the pressure of this form on a sheet of damp paper, form the two sections of the process; and both of these have in modern times been brought within the power of machinery.

From the earliest days of printing some kind of press has been employed to transfer the ink to the paper more readily and evenly than it could be done by hand. The kind of press first employed was nothing more than a common screw-press, such as a cheese-press or a napkin-press; together with some arrangement for bringing the form of type under the action of the press after it had been inked. This must necessarily have been a slow and tedious process; and as the screw must have come down upon the types with a sudden jerk, on account of there being no yielding or elastic support beneath, the pressure must have been so great as to endanger the letters.

The first notable improvement in this matter was the invention of the common printing-press by William Jansen Blaew, who, as a mathematical instrument maker at Amsterdam, had received encouragement and hints from Tycho Brahé, the great Danish astronomer. The press invented by Blaew, altered in a few minor points by later makers, became the common printing-press (Fig. 1421). In this press the chief points of difference, as compared with the older press, lie in the greater elasticity of many of the parts, so as to prevent the pressure from coming down with such a dead pull on the face of the types.

The "Stanhope press" is a much more efficient form of apparatus. This is represented in Fig. 1408, and on a larger scale in Fig. 1422. The object of the improvement was to render the printer able to produce a finer kind of work; for the rate of working remained pretty much the same as before—two hundred and fifty impressions on one side of a sheet in an hour. The body of the press is formed of a massive frame of iron, firmly fixed to a wooden foundation. The flat bed or table seen in the wood-cut is that on which the "form" of types is placed; and this bed, together with the "form" resting on it, is capable of being brought under the screw of the press. A kind of hinged cover is attached to one end of the table or bed: this consists of two "tympans," or stretched pieces of parchment, having layers of flannel between them, so as to form a soft and yielding surface. Hinged to the upper end of this tympan-frame is another skeleton frame called a "frisket," intended to retain the sheet of paper in a proper position to be printed. The action of these several parts is brought about in the following manner:—The sheet of white paper to be printed is laid flat on the tympan, and the frisket is folded down upon it; the "form" of types is inked; and the tympan, with the paper and frisket attached, is folded over and brought down in contact with it: the frisket being so regulated as to allow the paper to come in contact with the inked type. The whole is then brought under the press, and the screw worked by hand; the pressure is relaxed; the "form" drawn out; the tympan lifted up; the frisket opened; and the sheet of paper, printed on one side, removed. All this series of operations is repeated two hundred and fifty times an hour; so rapid are the movements which a practised hand can perform.

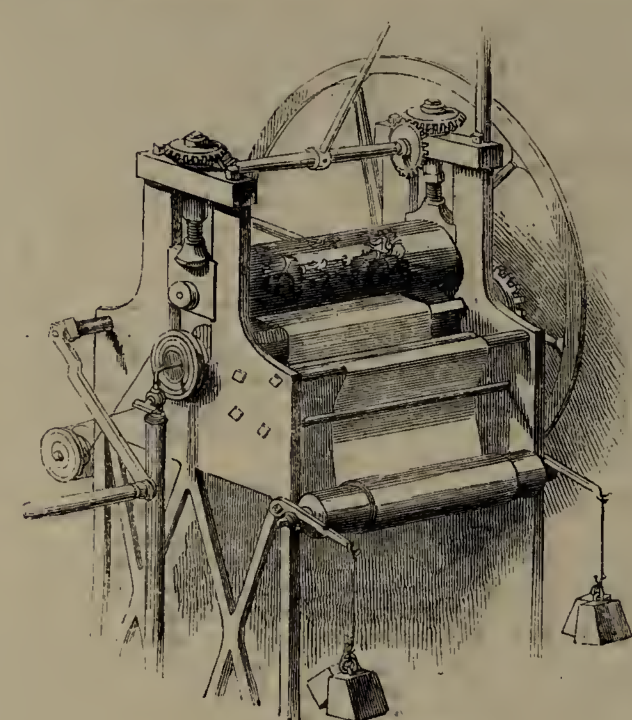
Many forms of press have been based more or less on that invented by the late Earl Stanhope, and named after him. These new forms have not been distinguished so much for the introduction of any new principle, as for better modes of managing some of the minor details. One kind, called the "Ruthven" press, is so constructed that the form of types remains stationary; and the "platten," or plate which is brought down upon it to produce the pressure, is removed when the form has to be inked. In the "Columbian" press the pressure is produced by a combination of levers alone, without the use of any screw.

We have not yet spoken of the mode of *inking*. It will of course be understood that it is only the *surface* of the types which requires to be inked: indeed the whole object of shaping them is to cut away certain parts which shall thereby escape the inking process. From the very outset of the printing process, until a few years ago, there seems to have been one uniform plan adopted. This was by the use of cushions or "balls," the making of which formed a necessary preliminary to the labours of the pressman. These balls were made of sheep-skin, or felt, which were often prepared in the printing-office itself; they were stuffed with carded wool, and brought to a very smooth and

1429.—Various processes of Bookbinding.

1430.—Bookbinding. (From an old Wood-cut.)

1431.—Embossing-Press.

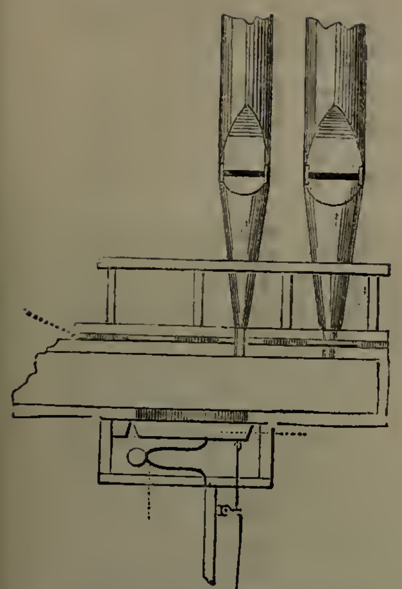


1432.—Cloth-embossing Machine.

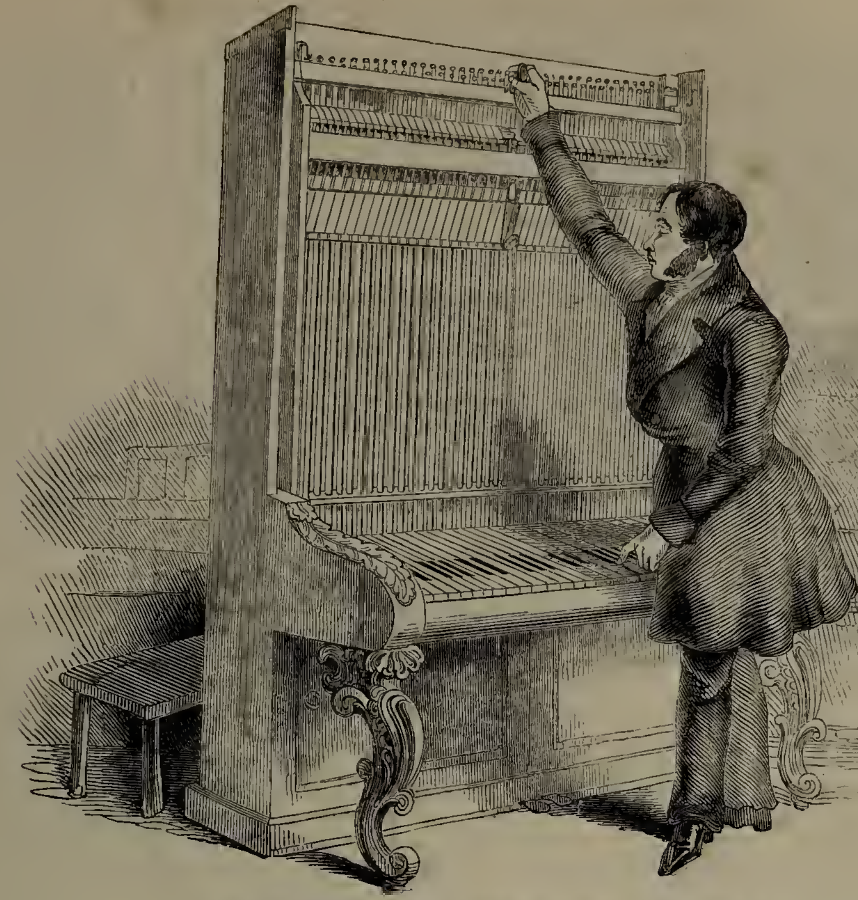
1435.—Cutting Pianoforte Keys.

1433.—Pianoforte Manufactory.

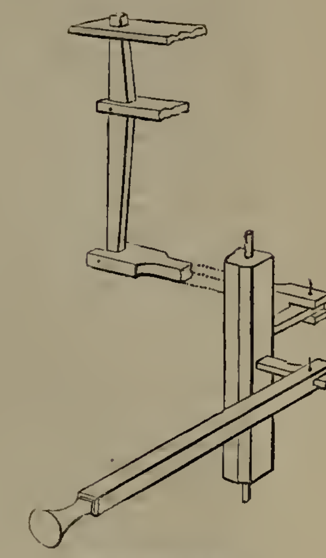
1434.—Ornamenting a Book after Binding.



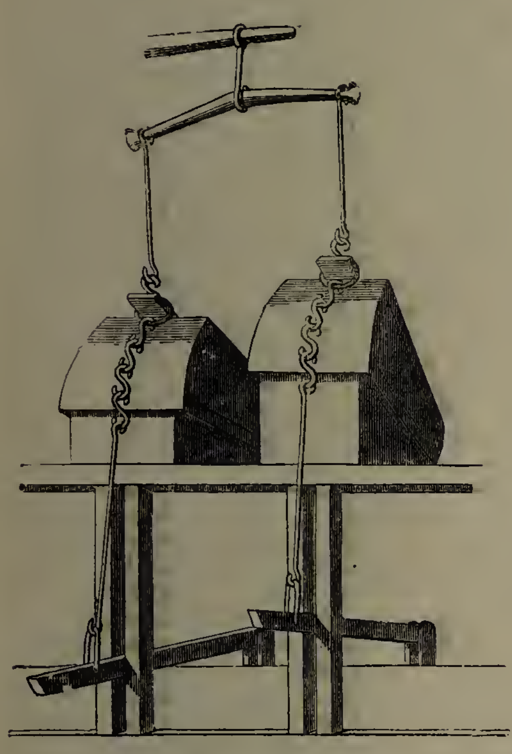
1439.—Pipes and Sounding-board of an Organ.



1436.—The "Action," or Internal Mechanism, of a Cabinet Pianoforte.

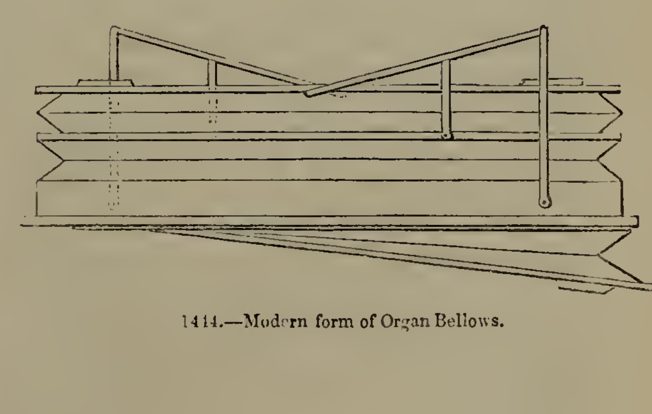


1440.—Mechanism of an Organ "Stop."

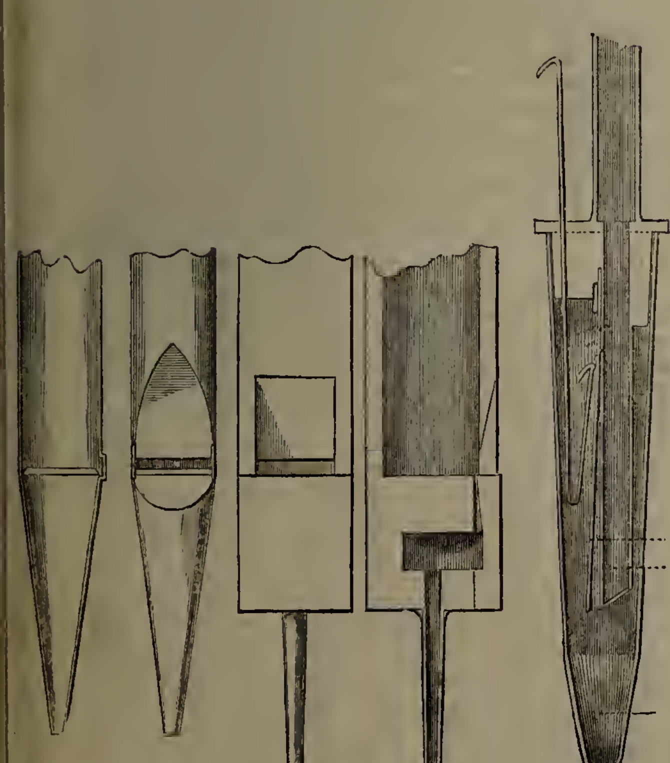


1441.—Ancient form of Organ Bellows.

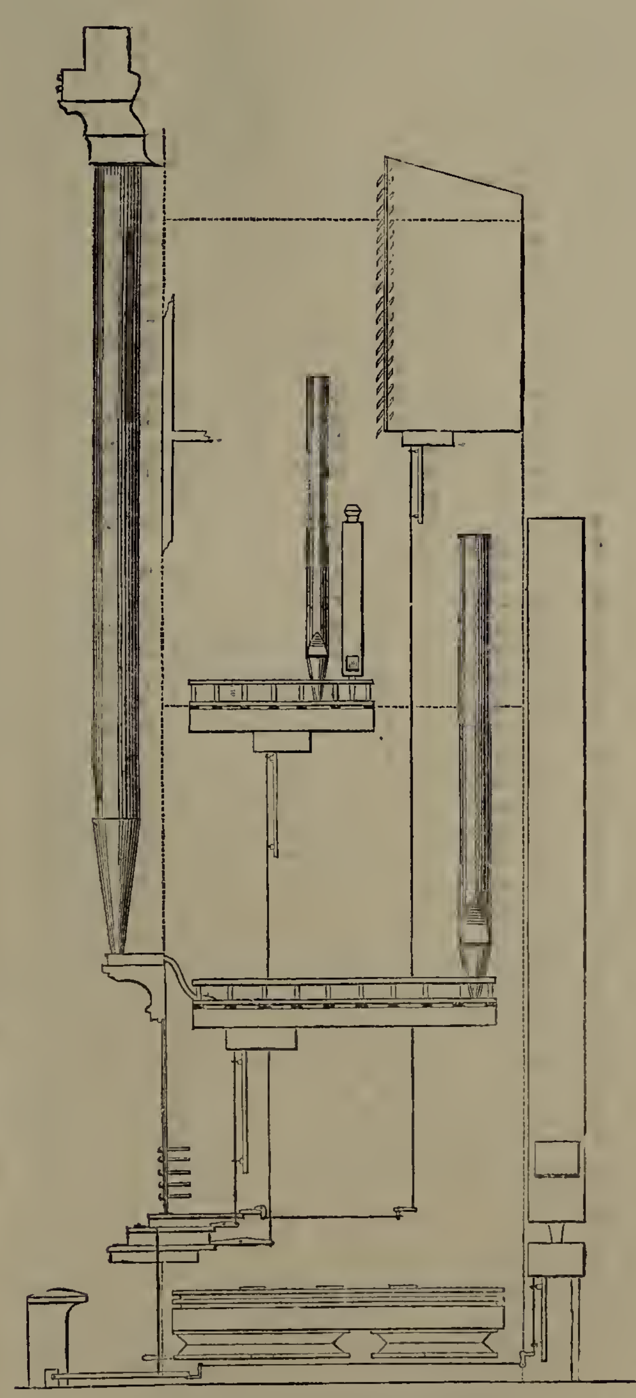
1437.—Cutting Fretwork for Pianofortes.



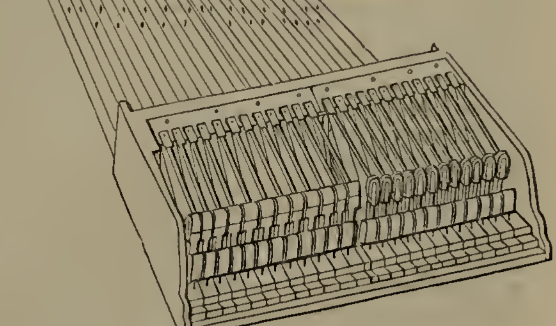
1444.—Modern form of Organ Bellows.



1442.—Various forms of Organ Pipes.



1443.—Vertical Section of a large Organ.



1438.—Treble "action" of a Square Pianoforte.

even surface. Besides the trouble of making them, these cushions required a serious expenditure of time every day, in order to keep them in a proper state for working. The time thus lost was not the only inconvenience resulting from the method; for the waste of ink was very considerable. The two balls are held, one in each hand; the ink is smeared or brushed over a flat table; the printer dabs the cushions down, as a means of collecting ink on them; and after rubbing them against each other, to equalize the thinkness of the ink on them, he works them over the surface of the form of types, until there is a thin film on the types sufficient for printing.

It may seem remarkable that such a clumsy mode of inking the types should have remained unaltered for so many years; but this is only one among the many examples afforded by manufactures, of the persistence of old habits of proceeding, where an occupation has arrived at that degree of uniformity which for so long a period distinguished printing. The mode by which this rude system has been superseded is by the adoption of a roller, made of a mixture of glue and treacle, and having a very considerable degree of elasticity; this roller is worked to and fro over the spread ink, until a sufficient quantity is taken up to ink the types.

Printing by the press, then, involves the following features:—The ink is spread out on a bed or cushion; and being thence taken up either by the inking-balls or the inking-rollers, is applied to the surface of the type. The form of types is so placed as to be inked conveniently; and the sheet of paper being adjusted in its place, is brought down upon the form of types. Pressure, either by a screw or by levers, then causes the impress of the inked types upon the paper. This leads to the printing of one side only; and to print the other side another form of types is used, and the paper is applied to it on the reverse side to that formerly applied.

Printing by Steam-Machinery.

The year 1814 witnessed an event of such importance to the art of printing, that without it the vast diffusion of cheap publications in our own day could not have taken place: we allude to the application of steam-machinery as a substitute for the hand-worked press. As two printers, working together at one press and its accompanying apparatus, cannot, as a general rule, print more than about two hundred and fifty copies in an hour, on one side of a sheet, or the same number of complete sheets in two hours; it follows that a work of large weekly circulation could not be printed fast enough, without a large number of presses, and an equal number of duplicates of the forms of type. The circumstance which in the first instance led to the adoption of steam-machinery in printing, was the wish to give in the morning newspapers as much as possible of the previous night's debates in the Houses of Parliament. It would have been of little avail for the reporters to acquire such skill as to make their notes while a speaker was addressing the house, and to place the results in a clear readable form in the hands of the compositors an hour or two afterwards, unless there were means of printing the paper very speedily when the type was set up. This speed, by the printing-press, was not such as to enable the newspapers to reach the hands of the readers until the day was far advanced. The printing-machine gives the almost marvellous power of placing on the breakfast table of a London reader a report of a speech delivered in Parliament at four o'clock the same morning!

We have said that it was in the year 1814 that this wondrous power became developed. Twenty-four years before that period, Mr. Nicholson invented a machine for inking the types and printing the sheets by cylinders; but from various causes he failed to bring it into operation. The idea, however, was not lost, for Mr. Kœnig, a native of Saxony, succeeded in surmounting the difficulties which had baffled Nicholson; and, having obtained the encouragement of the proprietors of the "Times" newspaper, he constructed a machine for printing that journal. Accordingly, on the 28th November, 1814, the reading world was supplied, for the first time, with a sheet of paper printed by steam-power. The machine invented by Kœnig, though very ingenious, was complicated and encumbered by a number of parts which later inventors sought to get rid of; it possessed altogether sixty wheels, besides numerous levers and other pieces of mechanism. The printing-machine now in general use was the invention of Messrs. Applegath and Cowper; and as it is most admirably adapted for the purpose, both in respect to inking and to printing, it has become very largely adopted, on the expiration of the original patent.

The printing-machine is represented in Fig. 1424. It consists of a considerable number of cylinders, round the whole of which the sheet of paper becomes necessarily coiled in the process of printing. The machine can print both sides of a sheet of paper at once; or rather, the sheet does not leave the machine till both sides are printed. There are two "forms" of type on the bed of the machine at one time: one, to print one side of the sheet, near one end of the machine; and the other, to print the remaining side, near the opposite end. These forms of type have been prepared very carefully, and adjusted to the bed or flat portion of the machine, which is strictly horizontal. Some of the cylinders are so adjusted as to work over the surfaces of these forms of type; while others are intended to aid the sheet of paper in passing from one "form" to another.

The operation of the machine requires the services only of a "laying-on boy" and a "taking-off boy." The first is seen mounted up near one end of the machine; while the hand of the second is seen removing a sheet of paper from beneath some of the cylinders. The "laying-on boy" places a sheet of paper on a flat table before him, with the edge of the paper in a position to be seized by one of the cylinders. The machine is set into motion; and while the sheet is carried forward by some of the cylinders, other parts of the apparatus are inking the types. At the first movement of the great wheel, a steel cylinder attached to a reservoir of ink begins slowly to move; another roller, called a "doctor," touches it, and receives from it a minute supply of printing ink; a flat surface, called the "inking-table," passes under this "doctor," and receives from it all the ink which the first roller had supplied; several "distributing-rollers" then work backward and forward on the inking-table, and spread the ink into a perfectly equal layer; after this another set, called the "inking-rollers," receive a supply of ink from the table, and then work this supply over the form of types which passes beneath them for this purpose. It will thus be seen that the number of transfers which take place before the ink is finally spread on the types is very considerable: they go in the following order,—the reservoir, the steel cylinder, the "doctor," the inking-table, the distributing-rollers, the inking-rollers, and the form of types. All these movements require a very exact adjustment of the machinery, and their general tendency is to cause the ink to be distributed with great regularity over the surface of the types.

Such being the mode in which the types become inked, the printing proceeds as follows:—The sheet of paper, laid upon a flat surface by the "laying-on boy," is caught by a web-roller, and conveyed to a series of endless bands or tapes, which pass it over the first "impression-cylinder:" it is here seized tightly by a series of bands, which fall between the pages and on the outer margin. The instant after the sheet has been seized by the first cylinder, the inked form passes under that cylinder; and the paper being thus brought in contact with the types, becomes printed on one side. To give the impression on the other side, the sheet is to be turned over; and this is effected by two drums, or cylinders, in the centre of the machine. The endless tapes never lose their grasp of the sheet, although they allow it to be reversed. While the impression has been given by the first cylinder the second form of types at the other end of the table has been inked; the drums have, during this inking, transferred the sheet from the first to the second cylinder: it is brought into contact with the inked types; and immediately afterwards the "taking-off boy" removes the sheet, printed on both sides.

For those who have the patience to follow the details of a diagram containing letters of reference, Fig. 1425 will illustrate more clearly some of the movements of the machine: the cylinders and rollers being represented as seen endwise. A sheet of paper, taken from the table A, is laid on the "feeder" B, which consists of girths of linen, tightly stretched by being passed round two cylinders. By the motion of this feeder the sheet is placed between the two systems of tapes which lie on the cylinder G: these tapes, of which one set is represented by the dotted line, and the other by the thin line, lie two and two over each other on the cylinders and small rollers *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, &c. The sheet of paper grasped between them is kept clean at the places in which it is in contact with them, and by the motion of the various parts is conducted under the first printing-cylinder H, and receives an impression from the types at C: thence, by means of the cylinders I K to the second printing-cylinder L, where it receives an impression on the other side from the types at D. Thus printed on both sides, it is removed. The cylinders at I and K are simply for the purpose of conveying the sheet steadily and smoothly from one printing-cylinder to the other. The sheet of course becomes reversed in its progress from one set of types to the other, descending the left side of the first printing-cylinder, and the right side of the second. The other letters relate to the inking-apparatus. The general bed of the machine is represented by M, N; while C, D represent the forms of type. These forms traverse backward and forward under the printing cylinders L, H, and also under the inking-rollers. The ink, received from a reservoir *k*, by the two rollers, *l* and *m*, is transferred from them to the surface of the table; this surface inks the rollers *n*, *o*; and these, in their turn, ink the types as the latter pass backward and forward from each impression.

Thus does this beautiful combination of machinery effect the printing operation, in a space of time remarkably short. Some of the machines now made can produce four thousand impressions in an hour by having the sheets laid on at four different points, instead of one, and by employing four printing-cylinders to press in succession upon one form of types.

Drying the Printed Sheets—Distributing Types.

There are a few matters of detail which may be here noticed, as they are independent of the particular mode in which a book is printed, whether by the press or by the machine.

The paper used in printing is not employed in the dry state; for, if it were, the ink would lie upon the surface and smear, on account of its oily composition. In a large printing establishment the "paper-warehouse" must of necessity contain an enormous quantity of paper, to keep up the supply as fast as the machines and presses require it. There was an account given in the 'Quarterly Review,' about six years ago, of the printing-establishment of Messrs. Clowes, where the present work is printed; and in that article the consumption of paper was illustrated in the following way:—"The supply of white paper in store, kept in piles about twenty feet high, averages about 7000 reams; the amount of paper printed every week, and delivered for publication, is about 1500 reams (of 500 sheets), each of which averages in size 389¾ square inches. The supply, therefore, of white paper kept in hand would, if laid down on a path of 22¼ inches broad, extend 1230 miles; the quantity printed on both sides per week would form a path of the same breadth 263 miles in length. In the course of a year Messrs. Clowes consume, therefore, white paper enough to make petticoats of the usual dimensions (10 demys per petticoat) for 350,000 ladies!"

The paper is piled up in heaps in the paper-warehouse, and is thence handed down, an armful at a time, to the wetting-room. Tanks or cisterns are contained in this room, having streams of cold water always running through them. A man opens a ream of paper, and dips each quire a few times in the water, regulating the degree of wetting to the circumstances of the case: the number of separate dips being from three to seven. As fast as they are wetted the quires are piled up one on another, and are then removed on a board to another spot, where they are allowed either to drain a little without pressure, or are exposed to the action of a press, as a means of removing superfluous water.

The wetted sheets are consigned to the hands of the "laying-on boy," if for machine-printing; or the "pressman," if for common printing. The printing is effected while the sheet is still damp, and in this damp state it is removed from the printing-room. In the large establishments there are steam-heated rooms, having a number of cross-bars and poles ranged in parallel lines. A man or boy, called the "hanger-up," suspends the damp printed sheets of paper on these cross-bars. He does this by means of an instrument called a "peel" (Fig. 1420); this consists of a broad flat piece of wood fixed to the end of a long handle. The edge of this "peel" is laid on a heap of damp printed sheets; and several of the sheets—five or six in number—are lapped over it; it is then moved sideways a few inches, and another portion is lapped over: and so on until the peel is full. The whole of the sheets, thus collected, are transferred to the poles or bars in the drying-room, where they become speedily dried sufficiently for binding.

Most modern periodical works undergo a little arranging and pressing at the printing-office, before they go to be stitched or bound. This arranging consists of "gathering" and "collating." On a long table are ranged heaps of printed sheets, each heap consisting of a great number of copies of the same sheet; and the heaps being equal in number to the sheets in the intended book, a boy, called the "gatherer," walks from end to end of the room, in front of the table, taking one sheet from each heap, and forming a group; so that by the time he has reached the end of the range he has collected exactly enough sheets to form one copy of the book. All the other groups he collects or "gathers" in a similar way. Then comes the "collater," who examines every sheet of every group to see that the proper order is maintained; this he does with astonishing rapidity; his examination being aided by certain letters or figures called "signatures," of which one is always put at the left-hand bottom corner of the first page of every sheet. For instance, p. 353 is the first page of the sheet which the reader now holds in his hand; and at the left-hand bottom corner of that page is the signature, consisting of one numeral and one letter (2 Z). If a volume consists of fewer sheets than there are letters of the alphabet, each sheet has a single letter to itself as a signature; but when there are more than this number the alphabet is taken over again, with the prefix 2 to prevent confusion. When again, the number of sheets exceeds this second application of the alphabet, the letters are used once more with 3 prefixed. The next following sheet of this volume, for example, will be 3 A. Printers are not uniform in the exact order of the signatures which they use; nor is this necessary, so long as the order adopted is well understood by those concerned in collating the sheets.

When the collater has examined each group, to see that it contains the proper quantity and the proper sheets for one volume, the group is folded into a thicker heap, and placed in a hydraulic press, where several such groups are made mutually to press each other. This hydraulic press (Fig. 1423), like others which have engaged our notice, contains apparatus for driving up the bed or stand on which the sheets are placed. There are two pumps, *b b*, worked by handles in the usual manner, and dipping at their lower extremities in the cistern of water, *a*; the water is pumped through the pipe *c* to a reservoir at *d*, where it exerts an upward pressure, which forces the piston *e* against the bed on which the sheets *f* are placed. When it is desired to remove this pressure in order to take away the sheets, a cock is turned at *g*, by which the water is allowed to flow back from the reservoir to the cistern. For the better kind of books, where it is desired to give a smoothness and glossiness to the paper, glazed millboards are inserted among the sheets before the latter are subjected to the press.

Before following these sheets to the bookbinder, it may be well to mention an office that falls to the lot of the compositor after the printing is completed. We have explained that the compositor keeps all the necessary types for his work in cases, which cases have a number of little cells, each cell to contain one letter of one kind of type only. When he has thus collected together and arranged in proper order all the types necessary for one sheet, and when he has made the necessary corrections suggested either by the author or by the "reader" of the printing-office, his duties terminate for the time, so far as that sheet is concerned. But they have again to be renewed at a later stage. When the printing of the prescribed number of copies is finished, or when a stereotype of each page has been cast, the form of type no longer requires to be kept whole; and the compositor then has the task of dissecting it piecemeal, in order that the separate types may be free to be used for some other purpose.

This breaking up of the forms of type, called "distributing," is nearly as remarkable in its way as the former "composing." Of this process it has been said, in the Penny Magazine, that "Probably no act which is partly mental and partly mechanical, offers a more remarkable example of the dexterity to be acquired by long practice. The workman holding a quantity of the type in his left hand as it has been arranged in lines, keeping the face towards him, takes up one or two words between the forefinger and thumb of his right hand, and drops the letters, each into its proper place, with almost inconceivable rapidity. His mind has to follow the order of the letters in the words, and to select the box into which each is to be dropped, while his fingers have to separate one letter from another, taking care that only one letter is dropped at a time. This is a complicated act; and yet a good compositor will distribute three or four times as fast as he composes; that is, he will, if necessary, return to their proper places 50,000 letters in a day. The letters, being inverted in printing, are not read as they are read in a book; and thus 'to know his p's from his q's' is a difficulty to a beginner."

The payment for the labour of a compositor includes both the composing and the distributing in one sum, so that it is equally important to him to be expert at both these operations to prevent loss of time. If in distributing he were to put the letters into the wrong cells, he would not suffer for his mistake at the time; but when afterwards he came to "set-up" or compose a new sheet, he would unavoidably make blunders, which would entail much correction; because, although he might dip into the right cells, he might possibly take wrong letters out of them.

Bookbinding.

The train of processes whereby the printed sheets are brought together in the form of a compact and convenient book, is not less interesting in some respects than the printing processes, though of course far less important.

All the sheets must be in some way sewn together before the covers or backs can be applied; or, if not sewn, some other mode of fastening must be adopted. Until the recent introduction of the mode of "caoutchouc binding," all books had the sheets fastened together by sewing; and indeed the change has not yet reached any considerable degree, for the number of sheets fastened by sewing is, beyond all comparison, larger than those cemented by caoutchouc.

The sewing is effected by means of small frames, or presses, such as the one sketched in Fig. 1428; and females are, in most cases, employed at this work. When the printed and collated sheets are brought to the bookbinder from the printer, they are slightly folded for the convenience of transport, but not in the form necessary for a book. The "folder" has, therefore, to be employed before the "sewer." The sheets are taken from the piles, or groups, one by one, and each one is folded into four, eight, sixteen, or more leaves, according to the size of the work: this folding is done with great rapidity, the sheet being doubled and doubled again and again, and the creases flattened and made regular by the application of an ivory or bone folding-knife, with a degree of quickness which the eye can hardly follow.

When the folded sheets are handed to the sewer, she places them, one by one, on the bed or flat surface of the sewing-press. This press consists of a stand or bed, from which rises two upright pillars, connected by a cross-bar at the top. Several strings, from two to ten or a dozen in number, according to the size and kind of book, are stitched tightly in a vertical position, being attached to the cross-bar at the top, and to the bed of the machine at the bottom. In fact, the object of the frame is very little more than to keep the strings stretched in a vertical position during the process of sewing the sheets to them. The sewer places one sheet down on the press, with its back edge next to the strings. She has a needle threaded with strong thread; and with this she proceeds to sew the sheet of paper to all the strings. She passes her left hand round behind the strings, and holds her right hand in front of them; and in this position, opening each sheet at the middle, she passes the needle to and fro through the sheet, in such a manner that the thread shall twist round all the strings separately. When this has been done, another sheet of paper is laid on the former one, and sewn in the same way: the thread being transferred from one sheet to the other without breaking. Thus the operations proceed, until all the sheets for one book are sewn together. Sometimes, in order to make the same strings serviceable to a greater extent, two or more volumes are stitched before the press is emptied, but without sewing the different volumes together.

This process is conducted so rapidly, that two or three thousand sheets can be stitched in a day by one workwoman. Sometimes the sheets are sewn to strips of vellum or leather; but in most cases common hempen string is employed; and four or five is about an average number for middle-sized books. When the sewing is completed, the upper cross-bar of the press is lowered by means of screws at the vertical posts, or else the strings are at once cut. The strings are sometimes intended to form small projections at the back edge of the book when bound, and in such cases they are left in the position which they naturally assume from the sewing; but in other cases it is desired that the back edge of the book should be quite smooth and level; and to effect this a few saw-marks are previously made to receive the strings. The sheets, too, before being sewed, are generally pressed heavily, to make the leaves lie close and compact together. This used to be effected by heavy hammers. In an old wood-cut, from which Fig. 1430 is copied, the bookbinder is represented thumping away most lustily. Such a method, however, has a tendency to transfer the ink from one page to another; and a system, at once more careful and more expeditious, has been obtained by the use of the "rolling-press" (Fig. 1419). A small number of sheets, made up into a packet, are placed between two tin plates, and passed between the two rollers of the press, whereby they become flattened and compressed to a much more solid and compact form than before.

In those instances where the leaves of a book are held together by caoutchouc cement instead of by sewing, the sheets are cut up into separate leaves, and every leaf made true and square at the edges. The back edge is then brought to a rounded form, by allowing the sheets to arrange themselves in a grooved recess or mould; and in that state the leaves are all moistened at the back edges with a cement of liquid caoutchouc or India-rubber. The quantity so applied is very small, but it is at the same time sufficient to enable all the leaves to cling very tightly together by their back edges, while the nature of the composition also gives considerable elasticity to the book.

When a book has been sewed (the other method being an exception to the general rule), preparations are made for attaching the cover to it. This is done in rather a different way, according as the book is to be put into "boards," or "bound." The strings are cut till a little remains at each end, and these ends are scraped or thinned, to render them as little visible as possible. The back edges of the book are glued, to render their adhesion yet stronger than by sewing merely; and before the glue is quite dry, the book has the roundness of edge imparted, by a process of hammering managed in rather a peculiar way (Fig. 1426): the book dries permanently in the form given to it by this hammering. About this point of the operations, too, the leaves are so pressed as to form two recesses or grooves for holding the stiff covers of the book. The boards or covers here spoken of consist of "millboard" formed of many layers or sheets of brown paper glued or pasted together, and rolled through a mill to make them smooth, hard, and firm. The sheets of millboard, made for the use of the bookbinder, are of various sizes, according to the sort of books for which they are intended to be used. They are cut up by means of the machine seen in Fig. 1427. A piece of board is provided, the exact size of the cover wanted; from this as a pattern, the millboard is cut up into pieces; the cutting instrument being a blade working in a hinge, something in the same way as in a chaff-cutting machine or a tobacco-shredding engine.

Books which are only put into "boards," to use a familiar expression, very seldom have the edges of the leaves cut true and even; but in a "bound" book the evenness of the edge is an essential feature. The cutting of the edges is effected before the covers are applied to the books. In former times the cutting was made by means of a sharp knife, which was guided in its movements by the edge of a sharp piece of board. The machine employed at the present day, however, is a much more efficient one. The book is screwed in a press in such a manner as to present the front edges of the leaves uppermost, projecting just as much as the quantity intended to be cut off. An instrument called a "plough" is then worked to and fro in contact with the edge of the book: the plough has a sharp cutting blade, the point of which speedily cuts off all the superfluous portion of the leaves. This cutting is effected equally on the top, the bottom, and the front edges of the book, but not exactly under the same circumstances. The top and bottom edges were ranged tolerably even in the first instance, and cut off square and true; but with respect to the front edge (or "fore edge" as it is called), this has unavoidably become concave in the process of making the back of the book convex. Now, in order to cut the fore edge, it must be rendered flat and square; to effect this the book is struck smartly on the convex edge, by which both the edges are rendered flat; and after being cut, the two edges spring back again to their convex and concave forms.

The pieces of millboard are attached to the book by means of the ends of the strings, in the case of a "bound" book, but by pasting with intermediate pieces of paper in the instance of a "boarded" book. In the former case holes are made near one end of the millboard cover; and the ends of the strings being passed through these holes, they are pasted down as flat as possible on the inner side of the cover, by which the latter becomes fastened to the book. After other minor processes, tending to give a neat and compact appearance to the boards, the book receives its covering, which is entirely of leather in a "whole-bound" book, and a combination of leather with either paper or cloth in a "half-bound" book. The leather employed is "Morocco," "Russia," "calf," "sheep," and a few other kinds, in most cases prepared by the leather-dresser to the state required by the binder. The skin of leather is cut to the required size, laid down on a smooth table with the face downwards, pasted at the back, and applied to the book, where by a very careful manipulation it is made to adhere closely to every part of the surface. Those books which have not "hollow backs" bend at the back edge whenever the book is opened; but most well-bound books are so treated, that, by the intervention of slips of pasted paper, the leather at the back edge is enabled to maintain its convex position whether the book be open or closed.

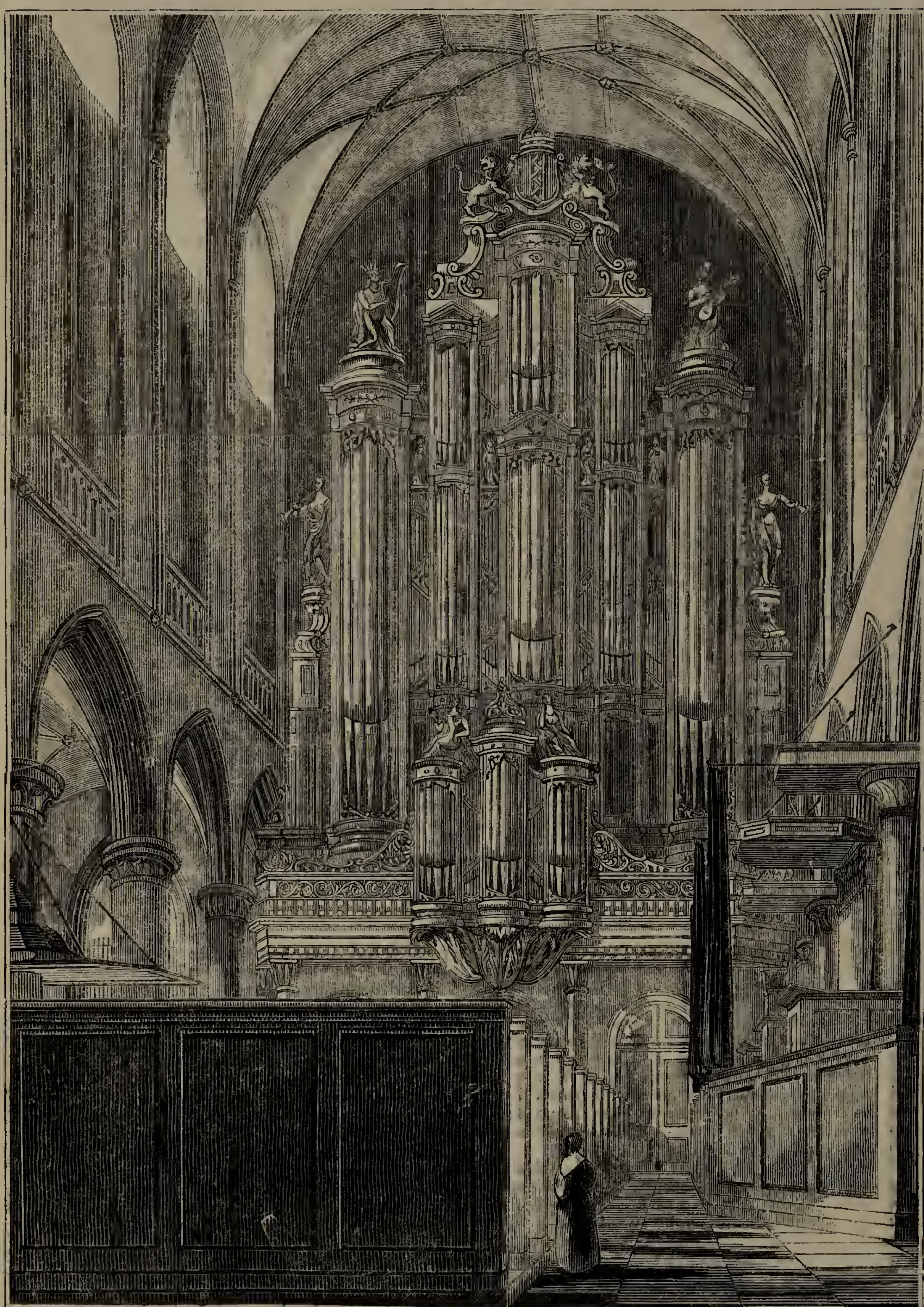
Where a book is put into "cloth boards" instead of "binding," the cloth is pasted to the millboard covers before the latter is attached to the book. The two pieces of millboard are adjusted at the proper distance apart to the cloth, and then fixed to the book mainly by means of the "end-papers," which are pieces of paper pasted both to the book itself and to the covers.

Both the cloth and leather almost uniformly receive some kind of decoration. The cloth for the covers of books frequently presents a speckled, chequered, or ribbed appearance, without any other particular device. In other cases there is an ornamental device impressed on the cloth, fitted to the size, and sometimes to the subject, of the book itself. These patterns are produced by embossing or rolling machines, such as in Fig. 1432; where there are two cylinders, engraved all over the surface with the requisite device, and placed so close together that when a piece of cloth is passed between them it becomes stamped or impressed. In some cases the pattern, with or without gold, is impressed upon the cloth after the latter has been pasted to the millboard covers. This requires a higher pressure, since it is necessary to act on the millboard as well as on the cloth. The engraved stamping surface is in this case flat instead of cylindrical; the cover is placed on a bed or slab kept hot by means of gas-jets; and the stamping-plate or die is brought down upon it by a press of immense power worked by two men (Fig. 1431).

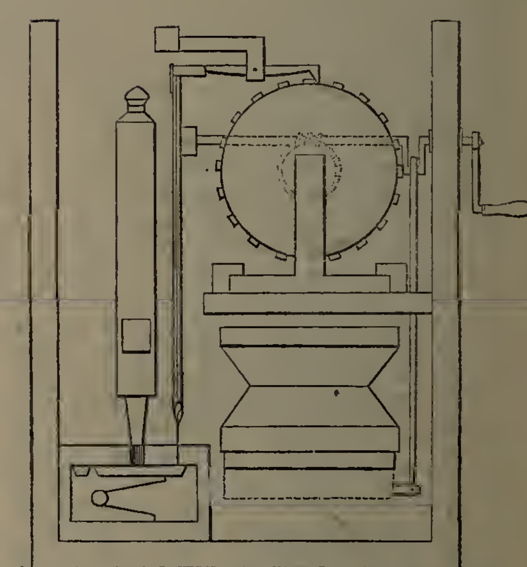
The gilt ornaments and lines on the back of a bound book are effected by means of small iron tools, which are engraved with letters, lines, scrolls, or any other devices. Many of these devices are engraved on the edge of a small wheel, so as to enable them to be worked in a very efficient manner. The gilder has a small stove heated by gas, at which he warms these tools. The leather is coated with size, then with white of egg, and then with a little oil; the leaf-gold is laid on in strips of the proper width, and the heated tools are immediately applied, by which the gold is made to adhere permanently in the proper places, while the remaining fragments are easily wiped off. Many modifications of the operation occur. Sometimes the wheel is employed, as in Fig. 1434, to give a running device; sometimes a small type or stamp is

1447.—Ancient Persian Harps.

1448.—New Zealand Musical Instruments.

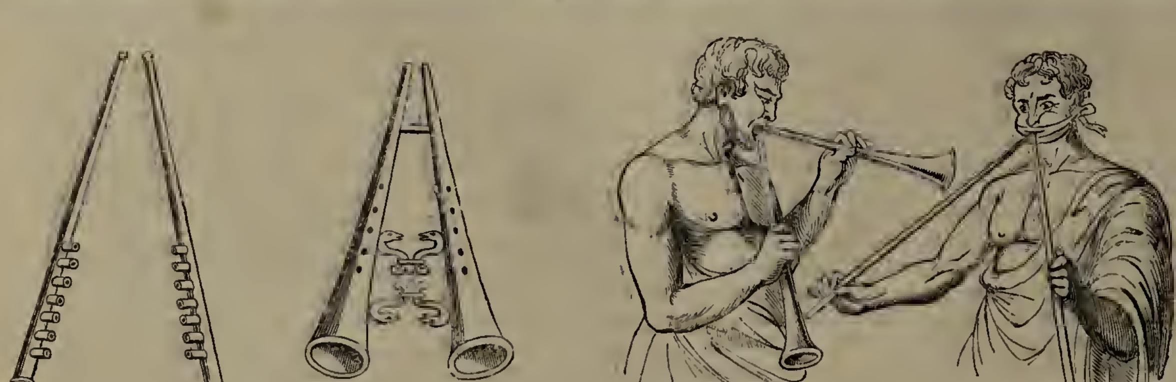


1445.—The great Organ at Haarlem.



1446.—Section of a common Barrel Organ.

1449.—Virginal (early form of Pianoforte).



1450.—Roman Double Flutes.

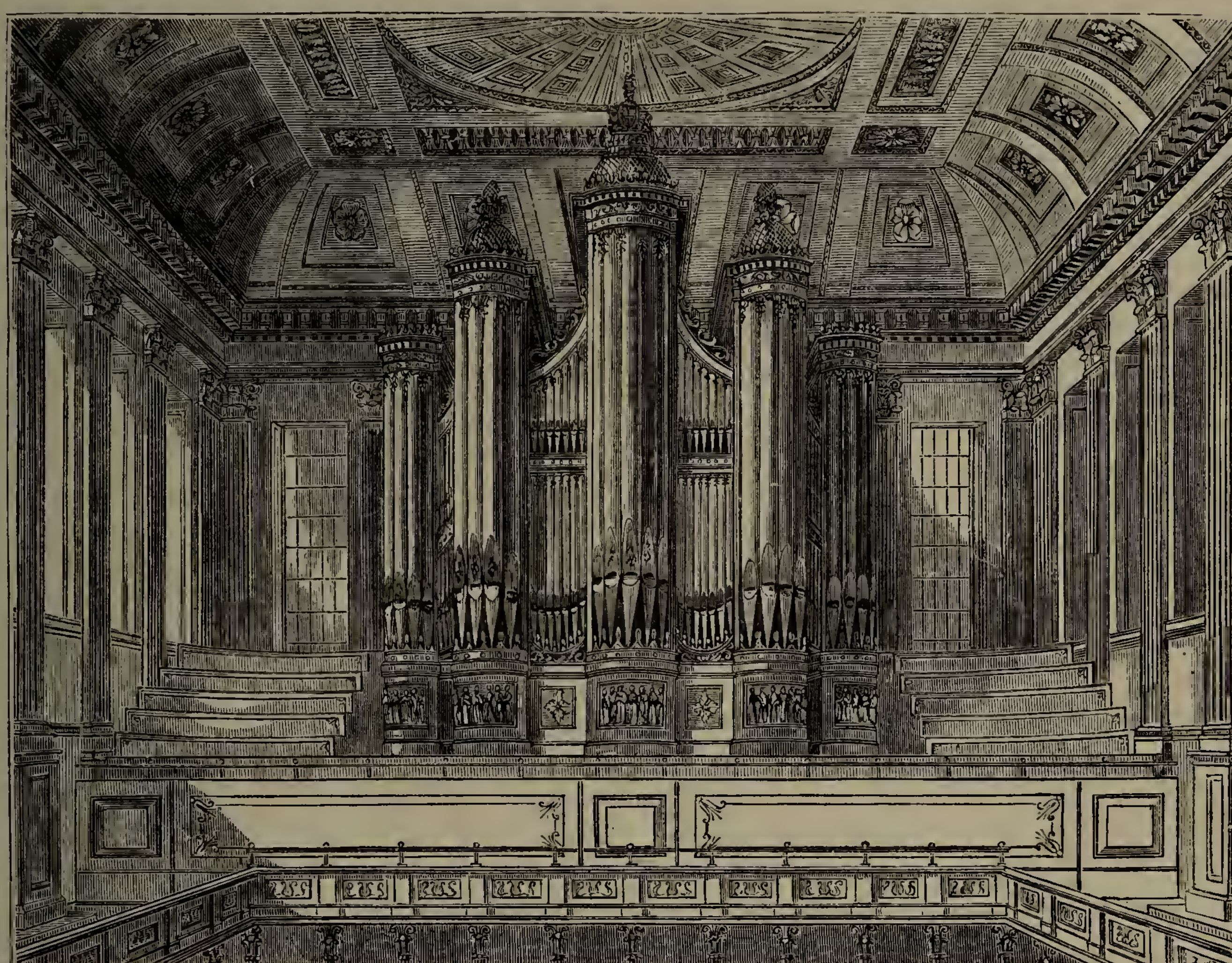
1451.—New Zealand Musical Instruments.

1452.—"Náy," or Flute of Modern Egypt.

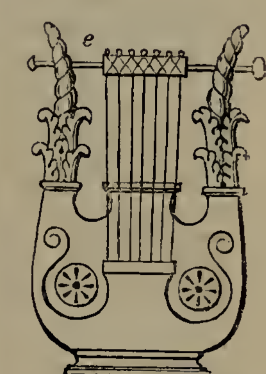
1453.—Bagpipes.—Time of Henry VII.

1454.—"Oo'd," or Guitar of Modern Egypt.

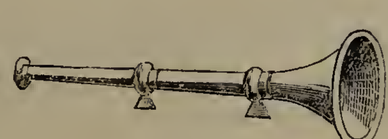
1455.—Ancient Lyre.



1456.—Organ in the New Townhall, Birmingham.



1457.—Ancient Lyre.



1458.—Ancient Trumpet.

1459.—Egyptian double-stringed Viol.

1460.—Greek and Roman Trumpets.

1461.—"Ḳánoon," or Dulcimer of Modern Egypt.

used singly; sometimes several small stamps or pieces are united into one "block," and this block impressed on the book; and sometimes the heated tools are applied without any gold at all, whereby depressed ornamental devices (called "blind-tooling") are produced on the leather.

The edges of books are diversified in many ways; some are "sprinkled" or "marbled" with a coloured paint, consisting of amber, red-lead, smalt, or such like colours. The books are so arranged on a bench that the edges of the leaves shall be alone visible, and the paint is applied by means of a brush and other tools, in such a way as to produce a uniform colour, a sprinkling, a resemblance to marbled paper, or any other diversified appearance: the colour being secured to the edge by subsequent application of egg or some other kind of varnish. When an edge is to be gilt, the book is temporarily distorted to bring the fore-edge flat, and is then firmly fixed in a vice or press. The edge is scraped smooth with a straight-edged piece of steel; then coated with a liquid of red chalk and water; and when this is partially dry, leaf gold is applied in strips of the proper width, by means of a flat kind of brush. In a very few minutes the gold is dry enough to be "burnished," which consists in rubbing it forcibly with a piece of very hard and smooth stone, held by a long handle. The gold becomes brilliantly burnished by this means, without its security being endangered by this hard rubbing. When the book is removed from the vice, it springs back again to its former shape.

Such are the more prominent among the rather numerous operations connected with the binding of a book: operations which give rise to a very busy scene in the establishments where they are conducted on a large scale. (Fig. 1429.)

Copper-plate and Steel-plate Printing.

There is a department of printing which, though it does not belong to the subject of books in so great a degree as that with which we have been hitherto engaged, is well deserving of a passing notice, viz. the printing of pictures or other devices from engraved plates of copper or steel.

The use of copper-plates for this purpose long preceded that of steel; the latter being comparatively a modern invention. In the preparation of copper-plates for the engraver, the copper, after being cut to the required size from a sheet of the best quality, is scraped all over with a steel instrument; it is then well hammered, to render it more dense and even; it is next ground with a piece of hard bluestone wetted with water, and is finally polished with carefully prepared charcoal, by which the surface is brought to a state so beautifully uniform, that the finest mark of the graver shall afterwards be visible on it.

The employment of steel plates has led to some curious and valuable results. Copper is perhaps the best material for the purpose, in an artistic point of view; but its softness renders it unfitted for yielding a large number of good impressions; and this circumstance led to the use of steel plates. Steel is, however, so hard, that the engraving of it is a matter of much difficulty. Contrivances of great ingenuity have been introduced for overcoming this difficulty, chiefly by the exertions of Mr. Perkins, an American gentleman. A plate or block of steel, half an inch in thickness, is "decarbonized" at the surface, that is, rendered so soft that a picture can be engraved on it by sharp tools. After the engraving, the steel is restored to its former degree of hardness, and "tempered" to a state found by experience to be best fitted for the object in view. A small cylinder of very soft steel is prepared; and this cylinder is rolled over the plate with such immense pressure, that all the engraved lines are copied in *relief* on the surface of the cylinder. This cylinder is hardened, and is again impressed on a thin plate of soft prepared steel: which plate, when properly hardened, becomes fit for printing. All this complexity of proceeding is only followed when an enormous number of copies is required from one plate: such, for instance, as bank notes or postage stamps. The hardened steel cylinder can be made to impress almost any number of soft steel plates; and each of these plates, when hardened, can be used in printing to an extent altogether beyond what copper could support. It was stated three or four years ago, that the device of the Queen's head on the postage stamps, although it had been engraved only once, had been transferred from a steel cylinder to no less a number than six thousand different steel plates, every one of which was fitted to produce a hundred thousand impressions upon paper before being worn out!

The above invention does not relate so much to steel engraving in common use, as to those cases where an enormous number of impressions are required. If only forty or fifty thousand copies were necessary, there would be no need of this complex series of operations; since a steel-plate, touched up once or twice with the graver, would produce this number; it is only where hundreds of thousands, or millions, of copies are required that the cylinder process is needed. In the common mode of proceeding, a plate of steel is very carefully prepared, and is then subjected to a process of decarbonization, by which the surface is rendered sufficiently soft to be either engraved or etched in the usual manner. In the earlier period of this important art, as introduced by the late Mr. Warren the engraver, it was found that the steel plate, when hardened after engraving, was too intractable, and too little fitted to accommodate itself to the exigencies of the subsequent operation. Means were found, therefore, of bringing the steel to such a state, that while it was soft enough to be engraved upon, it was sufficiently durable for the printing operations without undergoing any process of hardening. This is now the general plan acted on, and it has led to a great extension in the art of engraving on steel.

Such plates are engraved in two very different methods—by the *graver* or *burin*, and by *etching*. The graver is a very delicate and sharp steel tool, shaped at the point in different ways according to the kind of work to be executed; and with this tool the lines are cut which constitute an engraving. A scraper, a burnisher, a cushion, and a rubber, are among the small number of implements employed by the engraver. In the process of etching, however, there is a chemical action involved, which gives rather a different character to the art. The plate is first warmed, and is then thinly coated with a composition called the "etching-ground," formed of wax, asphaltum, gum mastich, resin, &c. This ground, when laid on and smoothed, is blackened by the smoke of wax candles, and is then in a fit state to be engraved upon. An outline of the design is made in pencil upon thin paper; and this paper being laid on the plate, and both passed through a press, the lines are transferred to the etching-ground with sufficient distinctness to be visible. Small tools, called "etching-needles," are then employed to execute the engraving, by scratching lines in the composition wherever a line is to appear in the print: laying bare the metal beneath, but not cutting it. A raised border of wax is built up round the plate, and dilute aquafortis is poured on: this speedily corrodes the copper in all the parts where it has been laid bare, while the composition prevents the corrosion from taking place elsewhere. The deep or strong lines require more corrosion than the faint lines; and this is brought about by a repetition of the process in some parts only, the other parts being shielded or protected by a composition called the "stopping-ground." In a carefully prepared etched plate, the "biting-in" and "stopping-out" are repeated several times. When all is completed, the etching-ground is removed, and the plate is in a fit state to be printed from.

There are various modes of engraving plates, known by the names of "line" engraving, "stipple" or "chalk" engraving, "mezzotint" engraving, and "aquatint" engraving. But without dwelling on these, or on certain variations in the mode of "etching," it is sufficient to say that the printing from these plates is effected in a pretty uniform way, let the mode of engraving be what it might. The plate, being brought to a proper state of smoothness and cleanness, is covered with thick unctuous ink, which is rubbed into the lines with a ball of cloth applied with considerable force. The superfluous ink is wiped off with a rag, and the surface of the plate is thoroughly cleansed by repeated wiping or rubbing with the palm of the hand, so as to leave the ink only in the lines or incisions of the plate. The plate is then passed through a rolling-press, by the action of which an impression of the engraving is transferred to a sheet of paper. It will be easy to conceive that this differs from type printing in the following way: that in the former the ink occupies the depressed parts only; while in the latter it occupies the raised parts only.

Colour Printing: Lithographic Printing.

Considerable advance has been made within the last few years in printing in *colours*. Where only one tint is produced, this involves no great difficulty, since it would merely require the use of a coloured ink or paint instead of black; but where many colours are combined in the same plate, mechanism of considerable nicety is required.

Let us take an instance in which four colours are needed. Four "forms" or copies of the picture are prepared, each one having in relief the parts required for one colour, while all the parts which correspond to the other three colours are left depressed or in intaglio. The four forms are hinged to a central compartment so exactly, that when brought down in succession upon a sheet of paper placed in that compartment, they would imprint that paper just in the proper order and position for the different colours. Supposing, for example, that one colour is brown, a block or plate is prepared for this brown colour, and is made to receive its thin film of colour in the manner of ink; the block is turned over so that it may print its portion of the device on a sheet of paper. Another colour, which we may suppose to be blue, receives its supply in the same way, and transfers it to the paper, but at places which had not been touched by the brown colour. So also in respect to the other two colours.

There are many different modes of effecting this kind of printing, not only with respect to the sort of block or plate employed, but also in relation to the kind of colour; for in one system the colours are really oil-colours, while others are gum-colours, or water-colours. It suffices, however, for the present object to know, that when a plate is printed in colours, the sheet of paper passes through the press as many times as there are distinct colours. In short, colour-printing for the pictorial art bears a strong resemblance to floor-cloth printing and to paper-staining, so far as regards the principle involved in the combination of the different colours.

Another remarkable kind of printing is that of *lithography*, in which the picture is engraved upon a flat stone, instead of copper, steel, or wood.

The whole theory of lithographic printing rests on these two circumstances: that certain kinds of calcareous stone are capable of imbibing both water and oil or grease; and that water and oil mutually repel each other. A peculiar kind of stone, and a peculiar kind of chalk or pencil, are requisite for the practice of this art. The stones are brought principally from the banks of the Danube, in Bavaria, and consist of a kind of calcareous slate which is easily split into flat slabs; some kinds have been found in our own country fitted for the purpose, but are not equal to those obtained from the Continent. The stone is porous yet brittle, and generally presents either a pale yellowish drab or a grey neutral tint. At the quarries whence they are obtained, the stones are split to an average thickness of about two inches, levelled at the upper surface, and squared to convenient sizes. They are then sold to other persons, who prepare them for use, by grinding two stones together, with a little water and sand between them; this grinding brings them quite flat and level; but at the same time gives the surface a granulated texture, which is necessary for the object in view, and is made coarser or finer according to the taste or requirements of the artist. This, then, is the stone employed; and the chalk or pencil, with which the design is to be made on the stone, is made as follows: it is a mixture of tallow, virgin-wax, soap, shell-lac, and lamp-black; these ingredients, by a careful process of heating in a close vessel, are made to combine into a uniform substance, and this substance is cast in a mould to such a form as is convenient for use as a pencil.

Supposing, then, an artist to be provided with a stone and a pencil thus prepared, he proceeds as follows:—He draws the design very carefully on the surface of the stone with the pencil, producing thereby a series of slightly greasy marks, owing to the soap contained in the pencil. These greasy marks are soluble in water, and would therefore wash out; but to prevent them from so doing, the stone is washed over with a weak solution of nitrous acid, which combines chemically with the soapy chalk-marks, and renders them insoluble in water. A solution of gum is floated over the surface of the stone; and when this is dry a wetted sponge is employed to bring the stone quite clean, but without removing the chalk marks. When the printing is about to take place, the stone is slightly damped with water, and is then inked with an oily ink pretty much the same as that employed in common printing; the ink is applied by means of an elastic roller worked to and fro over the stone. The water which had just been applied to the stone had been imbibed by the stone itself; but not by the chalk lines, because their greasiness repelled it: hence, when the inking roller is worked over it, none of the ink adheres to the stone itself, because that is wet; but it *does* adhere to the chalk lines, because they, like the ink employed, have an oily or greasy character. The result of this operation, then, is to ink all the marks of the design; and from thence an impression is taken on a sheet of paper by the action of a press. The greasy marks do not become obliterated for a long time; but, after each copy is printed, the stone is again wetted, and the inking roller again worked over it: the antipathy between grease and water being, throughout, the main feature on which the operation rests.

Printing by lithography in colours is sometimes adopted. In this case two or more stones are employed: one to give the main details of the picture, and the other the more delicate tints. The design (with these omissions) is made on a grained stone with the greasy chalk, and the printing from this stone is conducted exactly in the same way as in the former instance; but the printed paper, instead of being regarded as finished, is printed a second time from another stone, on which the lighter tints have been prepared in a more delicate manner. This employment of duplicate stones is not limited to the case of diversified colours being used, but is also employed for difference of shade or depth, when the colour is uniform.

Another variety of lithography is that which combines with it a process of etching. A coating of gum-water, coloured with lamp-black or vermilion, is thinly but evenly rubbed over a prepared stone; when dry, this coating repels all greasy or oily lines. On this gum-ground the design is executed with an etching-needle, precisely as in etching upon copper; and wherever the needle passes, the stone is laid bare.

After this, oil is rubbed over the surface, and is absorbed by the stone at the parts laid bare; whereas those parts which are still covered by the gum resist the oil. The gum is next washed off; but the oil resists this washing; and the result is that there is now a design sketched in pure oil on the stone; which oil will receive printing-ink just in the same way as the greasy chalk-marks had done. Thus there is here, again, an example of the curious effects produced by the antagonism of oil and water.

The finest *pictorial* results of lithography are brought about in one or other of the ways above described; but certain valuable *commercial* results are produced in a way yet to be described. This relates to the facility of copying letters, writings, and drawings, with great accuracy and speed: a power which has become very largely employed within the last few years. In such kinds of lithography, the stone, instead of being granulated at the surface, is smoothed and polished, by means of pumice-stone powder and water, applied with a piece of rag. The marking ingredient, too, is somewhat different, being a liquid ink instead of a dry chalk; it is formed of nearly the same kinds of ingredients as the chalk, but mixed in different proportions; and instead of being used dry, it is liquefied with water, and used either with a pen or a camel-hair pencil. The paper employed, likewise, is different, having a liquid gummy preparation washed over one side of it.

These being the materials, the transfer or copying by means of lithography is thus conducted. The device or writing (whichever it may be) is performed on the prepared paper, with a pen or pencil dipped in the prepared ink; and as the gummed surface will not allow the ink to penetrate to the paper, it gradually dries on the surface of the gum itself. When dry, the back of the paper is wetted slightly with sponge and water, by which the gum on the other side becomes moistened. In this state the paper is laid, face downwards, on a smooth polished stone, and both are passed through a press; the result of which is that the paper adheres strongly to the stone. Both are removed from the press; and on wetting the back of the paper, it is readily stripped from the stone; leaving on the surface of the latter, however, the coating of gum, and the device or writing in the greasy ink. The gum is washed off with water, and the ink marks then furnish a foundation, which may be printed from in the usual manner. In copying plans, letters, and official documents, this method has become very valuable: the document is written on a sheet of the prepared paper, with the prepared ink; and on being transferred to the stone, copies may be obtained on paper of the usual kind.

The recently introduced method of *anastatic* printing seems to depend, like lithography, on the mutual relations of gum, water, and an oily ink; but it has not yet attained such a position as to render a particular description of it necessary.

MUSICAL INSTRUMENTS.

Two out of the three groups of subjects into which this Chapter was proposed to be divided have now been rapidly glanced at. The first related to the means of rendering thoughts and devices tangible, or rather visible, by means of Writing and Drawing; while the second had relation to a similar record by means of Printing and Engraving. The remainder of the chapter will afford us an opportunity of noticing some of the aids which mechanical art renders to *Music*. As this matter can here only be entered upon so far as regards the shape, material, construction, and action of musical instruments; all consideration of music itself, as a branch of science, or as a polite art, is necessarily omitted.

The greater number of musical instruments may conveniently be collected into seven groups; of which we may take as representatives or types the Organ, the Clarionet, the Horn, the Pianoforte, the Harp, the Violin, and the Drum.

Wind-Instruments: the Organ.

An organ—whether such as is used in a church, or such as gives a livelihood to the poor Italians who wander about the streets—derives its action from the passage of air through pipes. According to the laws which regulate the production and transmission of sound, a body of vibrating air in a tube becomes more shrill or acute in pitch in proportion as the tube is shorter: hence, by a due management of the size of a set of tubes, all the notes for several octaves may be obtained.

But the possession of the right lengths of tubing is only one among many requirements for the production of an organ. A current of air must be excited: this current must be directed to a particular pipe at a particular time; it must act for a longer or shorter time, according to circumstances; and it must be set in vibration while in the tube. To produce all these effects requires a complication of arrangements such as would hardly be conceived by a person who had never seen the internal mechanism of these instruments—especially a large church-organ.

It will facilitate the comprehension of this matter to explain first the action of a common *Barrel* or *Street Organ*. In Fig. 1446, a pair of bellows is seen near the lower part of the machine. These bellows are worked by the handle of the organ; and wind is thereby forced into a little air-chamber or wind-chest, seen a the left hand of the machine. In small holes in the cover of this wind-chest are inserted the lower ends of all the organ-pipes; so that when the valve which closes the lower side of each aperture is opened, wind passes into the pipes. None of the valves can open without the action of the handle, which, besides working the bellows, acts upon the valves in a very curious way. There is a barrel studded with a number of small bits of wood and metal at its surface; and these studs, while the barrel is revolving, act in succession on a series of levers, which in their turn act on the valves that open the apertures in the wind-chest. There are as many levers to be acted on by the studs as there are valves in the wind-chest, and as many of these as there are pipes. The problem to be solved by the maker, then, after having collected pipes with the proper musical tones, is to open the valves just in the proper order for producing the right musical notes to form a tune; and the whole of this depends on the mode in which the studs are put into the barrel—a matter requiring singular nicety in its practical details. A barrel organ, a musical snuff-box, a church clock which plays psalm-tunes, and nearly all varieties of "self-acting" musical instruments, have a studded barrel to regulate the order in which the tones or notes shall be produced: however much they may differ one from another in other features.

In a *Church Organ*, which is not "self-playing," there is complexity of other kinds. The fingers of the performer act upon keys, and his feet upon pedals, which move certain levers; and these levers, by intervening mechanism, open the valves which allow air to enter the pipes. Sometimes the organist has an assistant to work the bellows for him, while at other times he works them with his feet. Thus, in Fig. 1443, the bellows are represented at the bottom of the organ, with a lever or pedal so connected with them as to be acted on by the foot of the organist. Above the bellows are various little scaffoldings or frameworks to support organ-pipes, which, in a large organ, differ greatly in size, and are placed in various parts of the machine. At the left hand near the bottom are seen the keys which are played upon by the fingers of the organist; and at the other end of these keys is the system of levers, the action of which opens the valves that admit air into the pipes. These valves, and the pipes above them, are shown a little more clearly in Fig. 1439. The lower part of the mechanism gives a section of the wind-chest, in which there is a spring so placed as to keep a valve close up to an opening in the top; when this spring is forced down, by means of wires, strings, or levers, air is admitted to a receptacle above, which contains the lower ends of all the pipes which are to be sounded at one time. As, in a piece of music, *melody* determines the notes which shall be sounded in succession, and *harmony* those which shall be sounded simultaneously, there is a very large and intricate arrangement of these pipes, valves, and levers necessary to meet the requirements of the musician.

Not only are there different *sizes* of pipes to produce different elevations of pitch, but different *kinds* of pipes to produce certain qualities of sound. It is this which gives rise to the organ-maker's technical name of a "stop." A "stop" is a set of pipes, all similar in the general character of the sound, but differing one from another as to pitch. Each particular stop has a name applied to it: such as the "flute stop," the "piccolo stop," the "diapason stop," &c.; and each of these kinds has a peculiar character—or as the French call it, *timbre*—belonging to it, wholly irrespective of difference of pitch. Some of the large organs have had a prodigious number of "stops" or sets of keys. The Apollonicon had forty-six sets, the Haarlem organ sixty, the Weingarten organ sixty-six, and the Pisa organ a hundred.

The variations in these qualities of tone are, as we have said, due to the construction of the pipes. Some of these peculiar tones are best produced from square wooden pipes open at the upper ends; others from pipes of the same shape, but closed at the upper end by a plug; others from metal cylindrical pipes; and others from *reed* pipes, that is, such as contain a little tongue or reed, or a slip of metal, which is so situated that the blast of air forced through the pipe sets the tongue into rapid vibration, and produces a quality of tone totally different from those yielded by pipes of the other forms.

Where the pipes become so numerous as they are in some large organs, it may be a matter of wonder how the organist can keep a command over them all. But he has each particular "stop" or set of pipes under his control through the medium of a small set of levers, such as that seen in Fig. 1440, of which there are as many as there are sets of notes; each one acting in a particular manner on the valves which admit air to the pipes.

A few of the different forms of pipes alluded to above are shown in Fig. 1442. One of these, having a spring inside, is so contrived as to modify the stiffness or elasticity of the vibrating tongue, and thereby modify the depth of tone at pleasure. With regard to the bellows employed, those sketched in Fig. 1444 will sufficiently illustrate their general form. There is contained in an old work a curious representation (of which Fig. 1441 is a copy) of a pair of bellows without leather; in which one wooden box or cavity is drawn down over another, and forced up again, in such a manner as to force air into a receptacle prepared for it:—at least such seems to be the mode of action; but no distinct description has been given of it.

The great organ at Haarlem (Fig. 1445) was built in the year 1738. It is a huge and magnificent instrument, having sixty "stops" or sets of pipes, many of which, in character or quality, are said to be almost unknown elsewhere. In a paper in the 'Penny Magazine,' concerning large organs, it is stated that "In the Cathedral of Seville, in Spain, there is an organ with 100 stops, which comprise 5300 pipes. The organ at Görlitz, in Upper Lusatia, has 82 stops, comprising 3270 pipes. That at St. Michael's, in Hamburg, has 67 stops, containing nine pipes of sixteen feet, and three of thirty-two feet, with four rows of keys; it was erected at the cost of 4000*l*. At Weingarten, a Benedictine monastery, in Suabia, there is an organ with 60 stops, which comprise 6666 pipes, seven of which are sixteen feet high and three thirty-two feet; it is stated that the monks were so delighted with their fine instrument, that they presented the builder, Gabelaar, of Ulm, with 6666 florins—a florin for each pipe—beyond the amount of his charge. The *old* organ at York was the largest in England: it had 52 stops, 3254 pipes, and three rows of keys. The largest organ at Rome is that in the Church of St. John Lateran: it has 36 stops. There is one in the Cathedral at Ulm that has 45 stops, with 3442 pipes. At Baltimore, in the United States, there is an organ in the Cathedral which has 36 stops, with 2213 pipes, the height of the largest of which is thirty-two feet."

The organ in the New Town Hall at Birmingham (Fig. 1456) is nearly the finest, if not *the* finest, in existence, taking its size and quality together. It is thirty-five feet wide, forty-five high, and fifteen deep. One of the pipes is thirty-five feet long by nearly two in diameter.

It is obvious that the mechanical arrangements involved in the construction of such gigantic instruments must be very intricate. The exact lengths and dimensions of the pipes, the choice of the wood and metal for their formation, the adjustment of so many valves, levers, stops, keys, pedals, &c., must render this an art calling for a large amount of skill. There must, too, be superadded a certain knowledge of acoustics as a matter of science, and of music as a practical study, to attain efficiently the object in view.

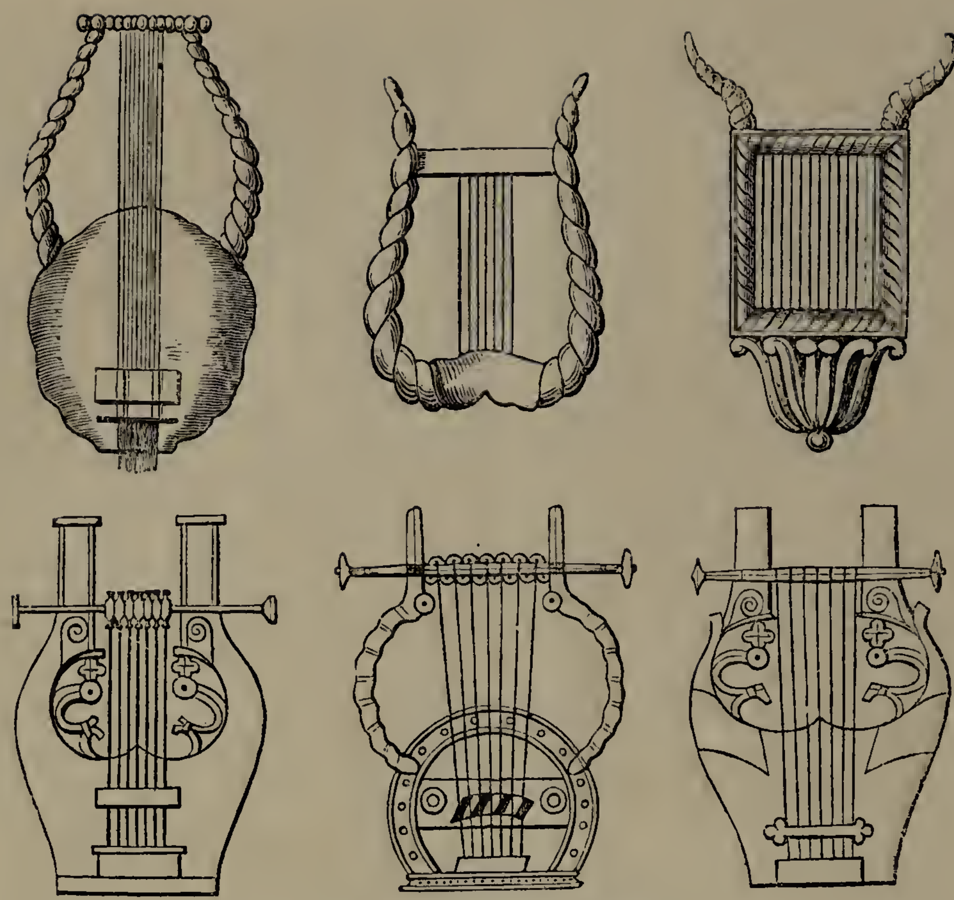
Wind Instruments, having a Vibrating Reed.

There are many musical instruments of considerable importance in an orchestra, in which the tones are produced mainly by the vibration of a small piece of metal or of reed in a tube, something on the same principle as one among the many kinds of organ-pipes.

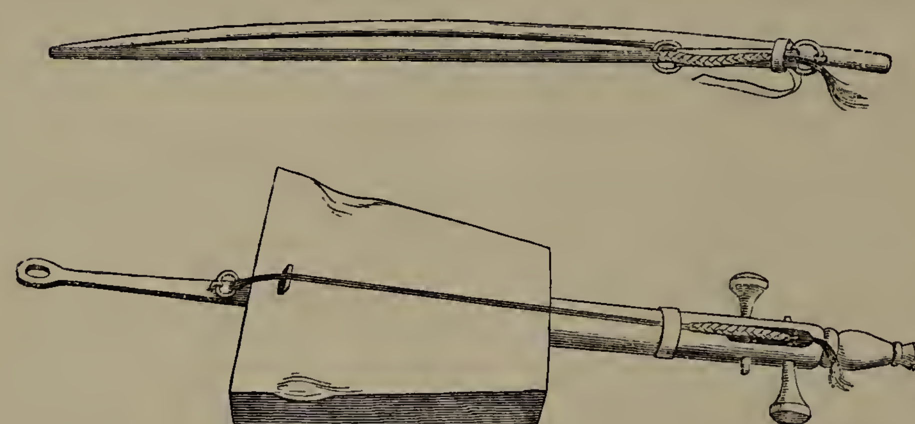
The *Clarionet* is perhaps the chief of these. This is, as everyone knows, a long wooden tube, expanding in diameter at its lower end, and contracting at the upper, with many holes and metal keys distributed at different parts of its length. The partition of the different tones and semi-tones of the octave is produced by the stopping of one or more of these holes, and the opening of one or more of the metal keys; but the production of the sound itself is due to the vibration of a thin reed or spring contained in the small end of the instrument. The breath of the performer, when impelled into the tube, sets this reed in vibration, and produces a musical sound; while the tube forming the general body of the instrument, and the increase or decrease of the effective length of this tube by the holes and keys, moderate the tones to the proper musical pitch.

The *Oboe* or *Hautbois* is another specimen of this kind. It is a tube of box-wood, rather less than two feet in length; expanding at the lower end like a clarionet, but not to so great a degree. It has holes and keys, and has also a reed in the mouth-piece; so that the general principle is much the same in the two instruments; although the practical details are varied in such a way as to lead to distinct qualities of tone. It is supposed that some such instrument as this, under the name of *Wayghte*, was in use in England in the time of Edward III.; and that the Christmas musicians called "Waits" derived their name from this instrument. The French name is *Hautbois;* the Italian *Oboe:* but both are usually alike pronounced *ho-boy*. The *Bassoon*, another valuable instrument in the orchestra, is in effect a bass oboe. The general body of the instrument is made of wood, and has holes and keys; but the reed, instead of being placed in a wooden mouth-piece, is contained in the end of a brass neck, or curved tube, projecting from the instrument. The Italian name is *Fagotto*, by which it is generally known in written music.

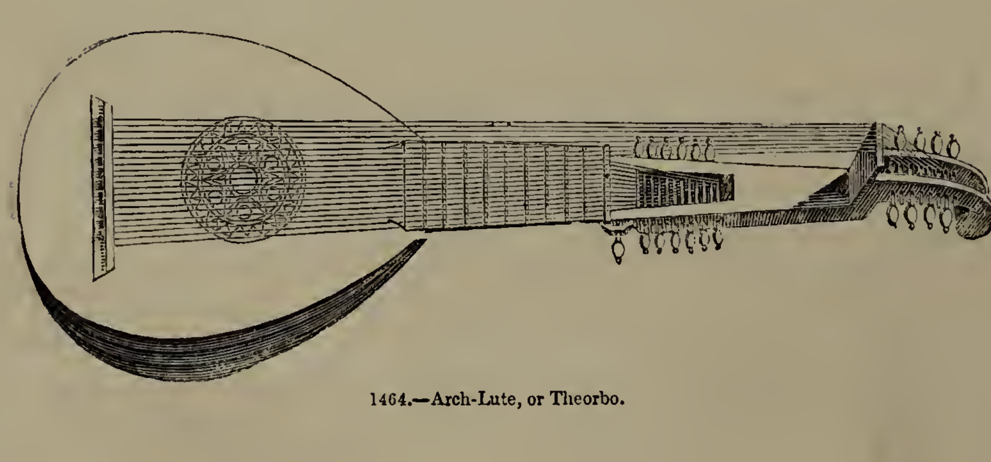
There are various arrangements of musical instru-



1462.—Various forms of Ancient Lyres.

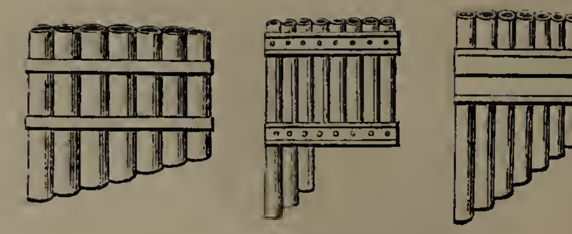


1463.—Egyptian Single-stringed Viol.

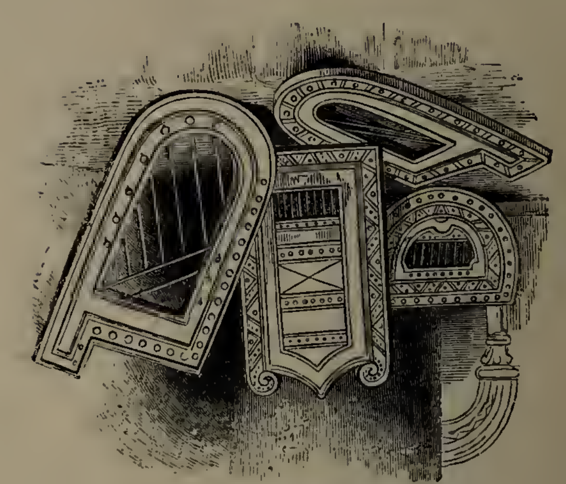


1464.—Arch-Lute, or Theorbo.

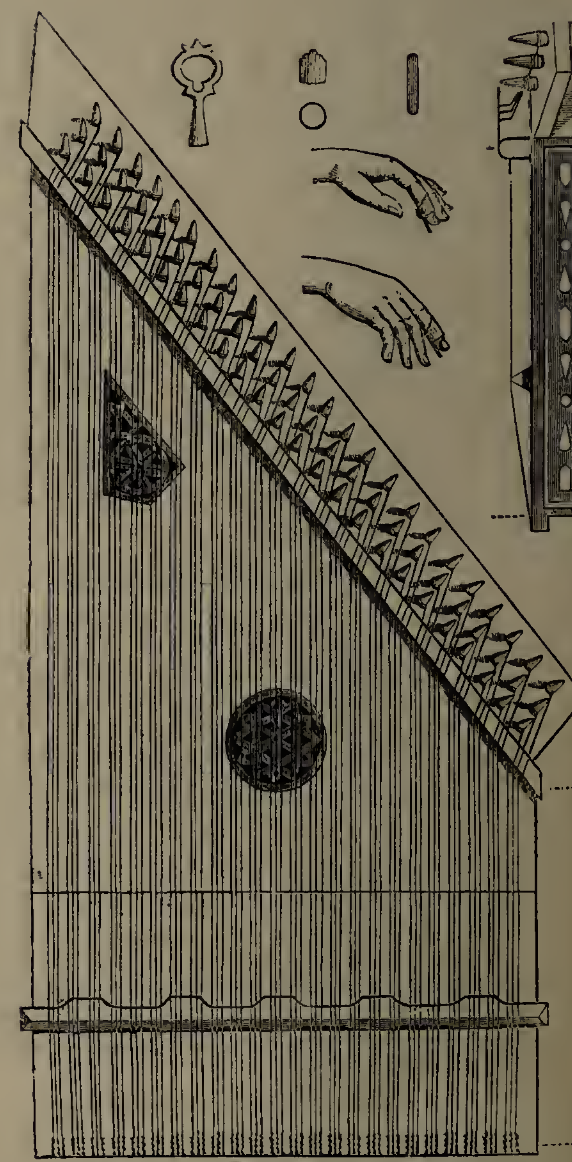
1465.—Oriental Tambourines.



1466.—Ancient Pandean Pipes.

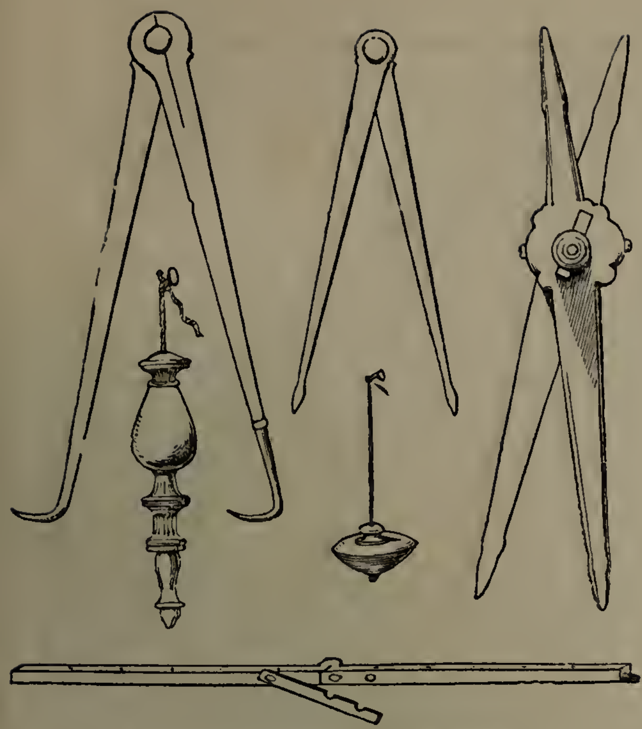


1467.—Danish Lutes.

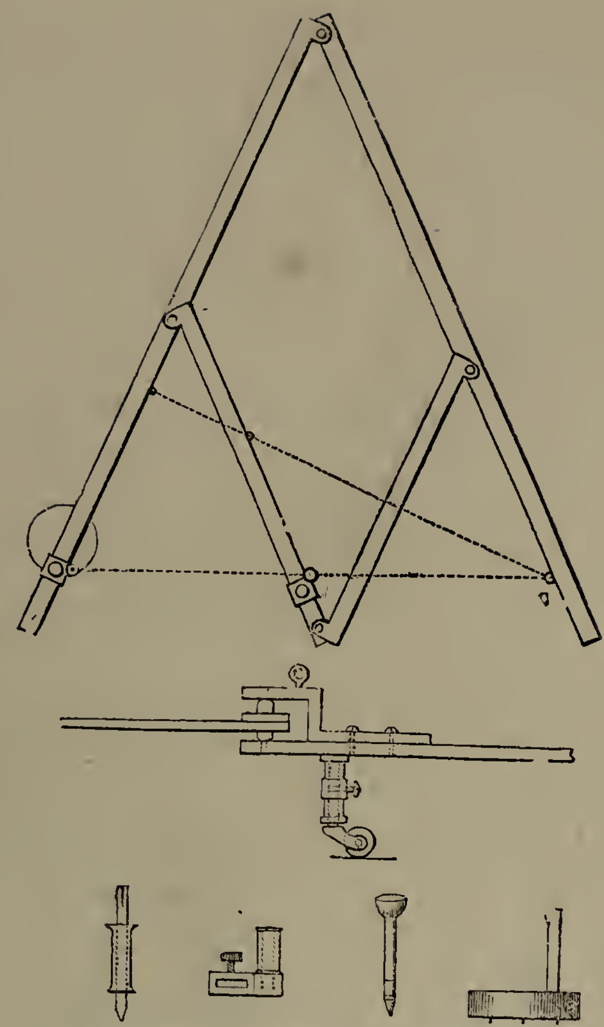


1468.—Mechanism of the "Ckánóon," or Egyptian Dulcimer.

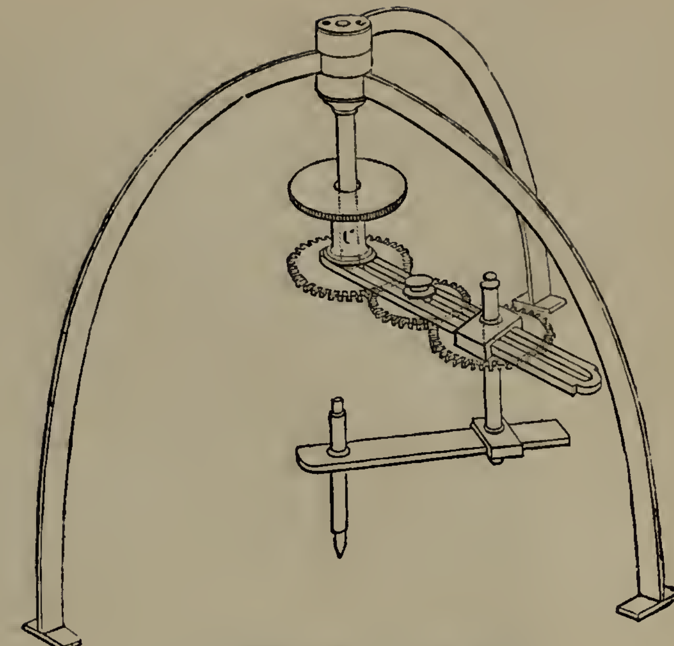
1469.—Viol di Gamba.



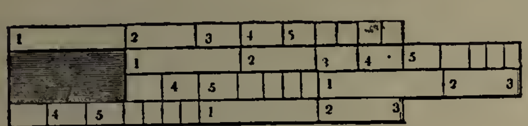
1470.—Drawing Instruments. (From Pompeii.)



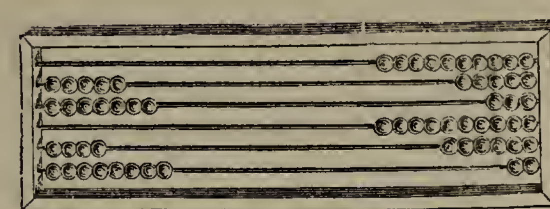
1472.—Mechanism of Pantograph, for copying Designs.



1473.—Geometric Pen, for drawing Curves.



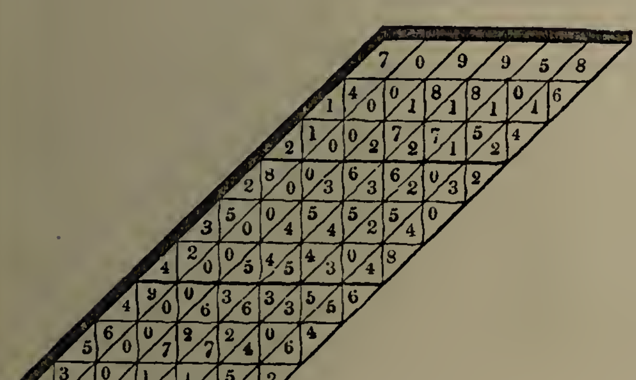
1471.—Sliding Rule.



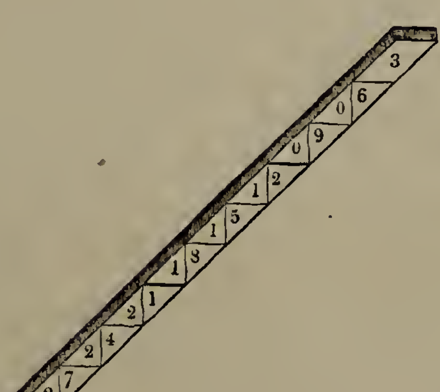
1474.—Abacus, a machine for reckoning numbers.

1475.—Figures produced by the Geometric Pen.

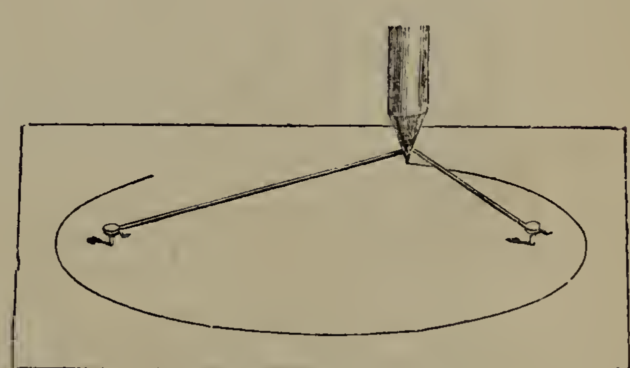
1476.—"Silhouette," or Profile-drawing Instrument.



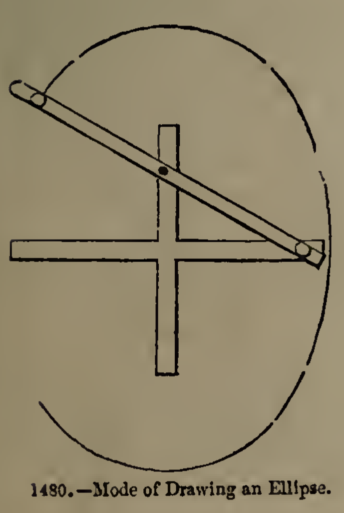
1477.—Napier's Reckoning Board.



1478.—Napier's Reckoning Rod.



1479.—Mode of drawing an Ellipse.



1480.—Mode of Drawing an Ellipse.

1481.—Arithmetical Board for the Blind.

1482.—Cubical Calendar. (From Pompeii.)

ments which depend a good deal on some such principle as the one here under consideration, although they do not at first sight seem to be at all similar. Such for example are the *Accordion* and the *Concertina*. In both of these instruments there is in the first place a kind of bellows, put in action by the two hands, in a way not altogether dissimilar from common bellows. The current of air thus excited (drawn from the external atmosphere through an opening in the instrument) is forced through a number of openings, in each of which a small steel or metal spring is placed. The rapid passage of the air sets these springs in vibration, and the vibration produces musical sounds. If the current of air were allowed to act on all the springs at one time, they would all be sounded at once; but this is prevented by the arrangement of a system of keys governed by the fingers of the performer, in such a way that he can open any one of the apertures, and thus cause the sounding of any one spring at pleasure.

The *Jews' Harp* and the *Musical Snuff-Box*, however different they may seem to be from each other, and from those instruments now under notice, depend mainly on the same general principle. There is in the former a long metallic spring or tongue fixed at one end and free to vibrate at the other. This spring is set in vibration by a touch from the finger; and when the instrument is held up in front of the mouth, all the air contained in the cavity of the mouth is set into vibration by the vibration of the spring. The different tones or notes of the octave are produced by a peculiar modification of the size of the cavity of the mouth, whereby the rapidity of the vibration of the air within is changed at pleasure. This may appear to be a most difficult thing to accomplished properly, and so indeed it is; but there was a player a few years ago, M. Eulenstein, who produced results of extraordinary beauty from this singular instrument.

The other instrument—the musical box—consists of a barrel studded all over the surface with little pins or wires. This barrel is made to rotate by the action of a coiled spring, just as in the case of a pocket watch; and, while rotating, the studs on its surface strike against a row of metallic springs, which are thereby set into vibration. All the springs are shaped and sized beforehand, so as to yield the proper tones; and the studs on the barrel are arranged in definite order according to the tune which is to be played.

In the manufacture of these instruments, having a vibrating reed, tongue, or spring, as the main agent for producing the sound, the length, thickness, and stiffness of these springs are important elements to consider. If a spring, of given dimensions in every part, were lengthened, it would yield a lower note than before; if, instead of being lengthened, it were increased in thickness, it would yield a more acute note; if, with the same length and thickness, the stiffness or rigidity of the material were increased, it would, as in the second case, give a higher note. All these points, therefore, besides those relating to the quality of the wood or other material of which the instrument in general is made, and to the mode of supplying the current of air, require a large amount both of practical and of inventive skill.

There is one singular instrument which seems to belong in part, though not wholly, to the present group, viz. the *Bag-pipes*. This instrument (Fig. 1453) consists of three pipes, two of which are called "drones;" each drone yields one continuous note of uniform pitch, while the third is a kind of oboe having finger holes to be played in the usual manner. The wind is applied not by the breath, but by a bag held under the arm, the alternate compression and dilatation of which forces air into all the three pipes.

Wind Instruments, having no Vibrating Reed.

There is a still larger class of musical instruments in which there is no vibrating reed or spring. The air is forced into them, generally with some considerable power, and is made to set the enclosed mass of air into vibration without the necessity for any springs.

Nearly all countries present examples more or less numerous of this class. The New Zealanders, before the present state of intercourse with the English commenced, were accustomed to make musical instruments out of wood, bone, and horn, and to carve them with various fanciful devices. Several examples of these are shown in Figs. 1448 and 1451.

The ancients had many varieties of *Flutes*, *Trumpets*, &c., all of which belonged to this class, under one or other of many different forms. The *Double Flutes*, seen in Fig. 1450; the *Trumpets*, in Figs. 1458 and 1460; and the *Pandean Pipes* (or, as they are often called in modern times, "Mouth Organs"), in Fig. 1466, are a few only among many specimens which might illustrate this matter. There are so many ways of producing sound in open tubes, that the early instruments of this kind seem to have been very numerous. If a tube be stopped at one end, and blown into obliquely at the other, a musical note may be produced (as may be proved by blowing into a small key); and by having many such tubes differing in length so as to produce different tones, a set of *Pandean Pipes*, or a *Mouth Organ*, would result. In the attempts to produce more than one sound from one tube, it would be found that if the tube were perforated at different parts of its length, the tube might be made to yield different notes, by stopping up one, some, or all of the apertures, at pleasure; and by making the apertures at proper distances apart, the notes yielded might be in the proper ratios for a musical scale. There is evidence that the ancients proceeded by some such steps as these; for their rudest wind-instruments seem to have consisted of the shells of some kinds of fish, the horn of some quadruped, an oaten straw, or a hollow reed, the perforation of which afterwards furnished them with the means of producing different tones from one tube.

It is difficult at the present day to determine what was the exact character of many of the musical instruments alluded to by the classical writers. The name *Flute* seems to have been given to many different forms of instrument, some of which are described as being straight, and others curved, small, middle-sized, single, double, right, left, equal, unequal, &c. Some of them were so formed that the player could perform on two at once; and he is sometimes represented with a bandage across his cheeks, the object of which may have been to concentrate the breath more strongly at a particular point.

The instrument known in England by the name of *Flute* has not uniformly been the same in shape. At one time the "English flute," or "flute à bec," had the upper end or mouth-piece curved like the beak of a bird. The modern kind, or "German flute," has no such appendage. It consists, as is well known, of a long tube, somewhat larger in diameter at one end than the other, stopped up with a cork at the wide end, and open throughout the remainder of the length. The air is blown into this tube by a particular direction given to the current of breath from the mouth into the mouth-hole: the musical sound is elicited by this current only, chiefly by striking against the edges of the mouth-hole of the flute. The six holes in the sides of the tube, to be stopped by the ends of the fingers, and the metallic keys, from one to sixteen in number (generally either four or eight), also played by the fingers, are intended for the modulation of the sound, so as to yield all the tones and semitones in a range of about three octaves. Some of the keys are intended to give greater correctness to many of the semitones, while others are designed rather to facilitate the performance of brilliant and rapid passages. The tube itself is made of box-wood, ebony, cocoa, ivory, and glass—generally one of the first three, the other two being mere curiosities of luxury. The adjustment of the metal keys (generally silver) to these tubes is a work of very great nicety, and indeed the whole of the details connected with the manufacture of a good flute call for considerable skill.

The *Flageolet*, like the flute, is a wind instrument played without a reed, but it is comparatively a poor affair, and has never maintained a position equal to that of the flute. It is held like the clarionet or the oboe, and is blown into much in the same manner; but the production of the sound, by the peculiar sort of vibration excited, bears more resemblance to that of the flute than to those of the reeded instruments. Some flageolets are double.

The "Na'y," or Egyptian flute, depends evidently on the same principle as the European flute, though held in a different position. Mr. Lane says that "it is a simple reed, about eighteen inches in length, seven-eighths of an inch in diameter at the upper extremity, and three-quarters of an inch at the lower. It is pierced with six holes in front, and generally with another hole at the back. The sketch which I insert of a performer on the 'na'y' shows the most usual manner in which this instrument is held; but sometimes the left hand is uppermost, and the instrument slanted towards the right arm of the performer instead of the left. The sounds are produced by blowing through a very small aperture of the lips against the edge of the orifice of the tube, and directing the wind chiefly within the tube. By blowing with more or less force sounds are produced an octave higher or lower. In the hands of a good performer the 'na'y' yields fine mellow tones; but it requires much practice to sound it well. A na'y is sometimes made of a portion of a gun-barrel." A performer on the "na'y" is sketched in Fig. 1452.

There are many brass instruments which differ from the flute both in the form, in the number of keys and finger-holes, and in the mode in which a current of vibrating air is excited in them; but still they belong to the general class which we are now considering, in having no reed or tongue. All the various kinds of *Horns*, *Trumpets*, *Bugles*, *Trombones*, *Ophicleides*, &c. are of this kind, and all have a peculiarity of tone which seems to be partly due to the mode in which the breath is impelled into them, and partly to the metal of which they are made.

The *Trumpet*, under one or other of various forms, has been in use from very ancient times, and in almost every country. As used in the modern form at the present day, in orchestras and military bands, the trumpet is a tube about eight feet in length, coiled up to a convenient form, having a mouth-piece at one end and an expanding curved opening at the other. The musical laws of this instrument are very remarkable; for the player has to modify the pitch of the notes produced by peculiar management of the current of air which he blows into it. The same may be said of a large number of *Horns*, however diversified may be their forms and appearance.

The *French Horn* is longer than the trumpet, being ten feet instead of eight, but it is coiled up into so many convolutions that it seems much shorter. It has no keys whatever; all the various tones are produced by one or more of three expedients—the degree of compression of the lips, the force of directing the current, and the insertion of the hand into the "bell," or wide end of the instrument. The last of these is a most difficult mode of fixing the tones and semitones of the instrument, since the slightest excess or defect of blocking up (if we may so express the effect of the hand in the bell of the instrument) will give a wrong tone. The *Bugle Horn* is just the same in principle as the French horn, but is less than half the length, and has fewer coils. The "post-horn," the familiar "newsman's horn" of past days, and many others, are simply various examples of the same general kind, modified principally by the length and curvature of the tube. The "Russian horn-band," which attracted so much attention some years ago, consisted of a number of performers, each of whom had one horn, with which he blew one note only, so that there were as many horns as there were different elevations of note to be played. These horns were simply straight conical tubes, in most cases without any keys or other appendages, and varying in length from two inches and a half (a mere whistle) for the highest note, to eight feet for the deepest.

But there are many instruments of the horn kind in which variations of the pitch of the notes are produced by keys—rather than by any of the contrivances mentioned above. The *Keyed Bugle*, for instance, is an instrument differing very little in size and shape from the common bugle which preceded it, but so provided with keys that it can be made to yield every tone and semitone in a range of about two octaves. The *Cornet-à-Pistons* and the *Cornopean* are two recently introduced varieties, which depend in great measure on the same principle as the keyed bugle, but are far superior to it in quality of tone, correctness of intonation, and compass or range. In these instruments there are pistons, which are pushed down so as to shorten the effective length of the tube, in a manner rather different from the keys of other instruments. The *Sax Horn* and the *Clavicor* are other examples of the same kind, introduced within the last few years, for combining the powers of a keyed instrument with the qualities of tone belonging to the horn or trumpet class.

The *Ophicleide* and the *Trombone* are two other varieties which may be here mentioned. The ophicleide is in a modern orchestra a substitute for the *Serpent*, now lessening in the extent of its use. The last-named instrument, which derives its name from its peculiar shape, is a conical tube of wood covered with leather, having a mouth-piece, a set of keys, and a set of holes for the fingers. It has rather an extensive range among the very lowest notes of the scale, and used to be much valued for the body of tone which it gave in concerted pieces of music. But there is a coarseness of quality in the tone, and this led to the substitution of the *Ophicleide* in place of the serpent in most concert and opera orchestras. The name Ophicleide signifies "keyed serpent," and the instrument so called is a brass tube about nine feet long, bent up to a convenient form, and having a mouth-piece like that of the serpent, a bell-shaped opening at the upper end, and ten keys. The instrument was first used at Paris about the termination of the last war, and was first employed in England at the Birmingham Musical Festival in 1834. It was said of this instrument at the time, in the 'Musical Library,' that it "proved eminently serviceable in the choruses, and whenever strength is required. The volume of sound it emits is immense; but the tone is rich, round, and blends well with the voices."

The *Trombone* differs from all the instruments noticed above in one remarkable feature—that the effective length of the tube is varied by the performer while playing, without either keys or finger-holes. It is in principle a trumpet with very deep tones; but it is formed of tubes which are made to slide one within another, and, by means of a short handle moved by the right hand of the player, these tubes may be made to slide in and out, so as to produce the length requisite for any particular note.

All the musical instruments of this group require great attention to the actual length of the tube, the diminution of diameter from end to end, the proper expansion of the bell-shaped opening, and the solidity and sonorous quality of the metal. The principle which regulates the production of the sound has been a matter for intricate mathematical investigation on the part of Professor Robison and others; but the makers of the instruments are guided chiefly by past experience in the plans of construction followed by them.

Stringed Instruments, played with Keys.

The large and important system of musical instruments to which a little attention may next be directed, admits of a convenient subdivision into three groups, of which all will be alike in respect to the production of the musical sounds from strings, but differ in the mode in which the strings are made to vibrate: one by means of *keys*, like the pianoforte; another by means of the *fingers*, like the harp; and the third by means of a *bow*, like the violin.

The *Pianoforte*, the most generally admired and employed among all musical instruments at the present day, has arrived at its present state by many gradations. As far back as three centuries ago there was an instrument of this class in use in England, known by the several names of the *Clavichord*, the *Manichord*, and the *Dumb Spinet*. This was an oblong case, having keys something like those of the pianoforte. There were as many strings as there were keys, and the hinder end of each key had a little brass wedge, which struck against the string, and elicited a sound from it; the strings were muffled with small pieces of cloth, which gave a subdued expression to the tones.

The *Virginal* (Fig. 1449) seems to have been very similar to the clavichord. It was a favourite instrument in the days of Queen Elizabeth, who is said to have prided herself on her skill in playing it: indeed the virginal which had (as is supposed) actually belonged to her, was in existence a few years ago, and was fully described in some of the public journals. The instrument in question was contained in a case of cedar, covered with crimson Genoa velvet, upon which were three ancient gilt locks finely engraved: the inside of the case being lined with yellow tabby silk. The front was covered entirely with gold, having a border round the inside two inches and a half broad. The case was five feet long, sixteen inches wide, by seven inches deep; and was so lightly and delicately formed, that the weight did not exceed twenty-four pounds. There were fifty keys, provided with "jacks" and "quills;" these "jacks" were little pieces of metal or of wood attached to the hinder ends of the keys; while the "quills" were small pieces of quill or of horn for striking against the strings. Thirty out of the fifty keys were made of ebony, tipped with gold; and the remaining twenty were elaborately inlaid with gold and ivory. The royal arms were emblazoned in ultramarine, carmine, and gold.

Another form of instrument, of later date than the above, was the *Spinet*, or *Horizontal Harp*. This was shaped more like a harp laid flat on its side than like a modern pianoforte, being a three-cornered instrument, with the key-board placed at one of the diagonal sides. The front ends of the keys were pressed down by the finger, as in other cases; but the hinder ends acted on the strings by means of "jacks" and "quills," as in the virginal, and not by means of hammers, as in the pianoforte. These instruments usually contained about four octaves, or fifty semitones, which were produced from an equal number of strings, one to each note. The strings for the lower notes were made of brass wire, and those for the upper of iron or steel wire.

The next form which this class of instrument assumed was the *Harpsichord*. This differed from the former in having two strings for each note instead of one, thereby strengthening the tone; the keys acted at the hinder end by jacks and quills, as before, but the instrument was larger than any of its predecessors. At one time there were very large instruments made, under the name of *Double Harpsichords*, having three sets of strings and two sets of keys, to give the performer a power of producing varied effects at pleasure. The quills gave the strings a smartness of touch which led to the production of very sprightly tones; but it was sometimes sought to render the tone softer and sweeter by muffling the quills with leather. Many of the great composers of the seventeenth and part of the eighteenth centuries based their compositions on the harpsichord, as a convenient form of instrument.

From this instrument sprang the *Pianoforte*—one which has succeeded in maintaining its position as the chief among domestic musical instruments. The great change here consists in striking the strings with a soft hammer instead of with a hard quill. Some historians of music give the credit of the invention to an English monk at Rome, named Padre Wood, in 1711; while others give it to a Bohemian named Christopher Gottlieb Schröter, in 1717. Both may perhaps be right, for the idea is one which was very likely to occur to different persons independently of each other. The power of producing soft and loud, or "piano" and "forte" effects, is said to have led to the choice of a name for this new instrument; but this choice is anything but a felicitous one.

From the time when the pianoforte became established in this country to the present day there has been scarcely a year which has not produced some improvement or addition to it, until at length it has come to be a most intricate piece of mechanism. There are five different kinds of pianofortes made, similar in the use of hammers to strike the strings, but differing in minor particulars. The "square" pianoforte has the strings ranged horizontally in a rectangular case, two strings to each note, and having a range of five and a half, six, or six and a half octaves—the lowest of which equals the greatest used in the old harpsichords. The "cottage" form has the strings ranged vertically, reaching nearly from the ground to a short distance above the level of the keys; the case is shorter and higher than that of the "square;" there are two strings to each note, and the compass is generally six octaves. The "cabinet" pianoforte is very lofty, having the strings ranged vertically, and elevated wholly above the level of the keys; there are two strings to each note, and the compass is from six to six and a half octaves. The "grand" is a very long instrument, having the strings ranged horizontally, and the keys at one end of the case; there are *three* strings to each note, and a compass of six and a half octaves. Lastly, the "semi-grand" pianoforte is formed on the general plan of the "grand," but with a limitation to six octaves in the compass, and having only two strings to each note.

The interior mechanism of these instruments, in order to enable the player to strike either one, two, (and in some cases three) strings with one key, and to give varying degrees of softness to the tones, is very intricate. The manufacture involves very large arrangements, and some of the factories devoted thereto are among the largest in London (Fig. 1433). The selection and drying of the various kinds of wood, the working of these into the proper forms, the manufacture and stretching of the brass and steel wire for the strings, the adjustment of the numberless little pieces of wood, metal, and leather, to the mechanism at the hinder end of the keys—all tend to render this a very complex department of manufacture. In some instances it is merely a species of cabinet-work, such as sawing the keys from a flat piece of wood (Fig. 1435); or of carving, such as cutting the ornamental fret-work for the case of the instrument (Fig. 1437); but in many instances it is difficult to say under what class the operations come. As to the intricacy of the details, it will suffice to refer to the "action," which is a general name for the mechanism that intervenes between the keys and the strings, to communicate and to modify the tones. In Fig. 1438 we have part of the "action" of a square pianoforte; while in Fig. 1436 is shown only a small part of the "action" of a cabinet. As an illustration of this complexity, it is stated that in one of Messrs. Broadwood's most complete cabinet pianofortes, "them echanism connected with the "action" consists of about *three thousand eight hundred* separate pieces of ivory, ebony, cedar, sycamore, lime-tree, mahogany, beef-wood, oak, pine, steel, iron, brass, lead, cloth, felt, leather, and vellum. Every one of these has to be fashioned with the most scrupulous exactness, and as scrupulously adjusted to its place. Many of the pieces are not more than a quarter of an inch square, some even less. The qualities of all the varieties of wood are closely studied, in order to determine their particular aptitude for the different parts; and it is thus that so many as seven or eight kinds are used in the "action" alone. One kind is preferred because slender rods made of it will not warp; another kind because the grain is straight; a third because it is hard and smooth; a fourth because it is soft and smooth, and so on. Some of the rods are as much as three feet long, and only a sixth or seventh of an inch in thickness."—('Penny Magazine.')

There are other instruments which might be deemed as belonging to this class, viz., those which have strings sounded by means of the pressure of the fingers on a set of keys. Such are not, however, of very general importance; and it will suffice here to allude simply to the *Monochord*, or *Hurdy-gurdy*. This consists of one stretched string, which is set in vibration by means of a small piece of mechanism attached to the handle, which is rotated by the hand. If this were all, the string would yield one note only; but there is a key-board, each key of which acts on a lever that presses on the string, and effectually shortens its vibrating length. According to the principles which govern this matter, the shorter the length of the vibrating portion of a string, the higher or more acute is the note yielded; and the several keys are, therefore, so arranged as to act upon the string at the proper points for shortening it (only temporarily, of course, and so long merely as the finger is pressing on the key) in the degree necessary to produce the proper musical notes.

Stringed Instruments, played without Keys.

Although the pianoforte is the most generally acceptable of all stringed instruments, yet the number of those which are played without the aid of keys is much larger than of those, like the pianoforte, which are played with keys. A very few details will suffice to show the general principle involved in such instruments, though the varieties of form may be numerous.

The *Harp* is, perhaps, the most important instrument of this class. From very early times some such have been used, either in the comparatively simple form shown in Fig. 1447, or in more elaborate forms.

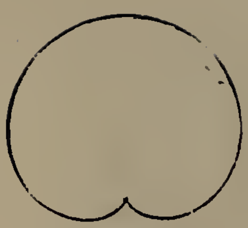
Whatever may be the form of the harp, it was formerly a general principle of the instrument that each string should yield one note only, as in the pianoforte; but the mode of arranging the tones of the different strings varied greatly. The harps which were in former days so much loved in Wales were of three different kinds—single, double, and treble: the last-named of these contained three sets of strings, of which one was for the right hand, and another in unison with it for the left, while there was a third row between the other two for the semitones. The Irish harps were in like manner very diverse in their form.

In the harp of modern times the ingenious and valuable feature consists in giving to each string the power to yield two or three different tones instead of one only. The instrument embraces so many octaves within its range, that if there were as many distinct strings as there are semitones in these octaves, the harp would become almost unmanageable. The earlier and ruder harps had a smaller compass, and there was, therefore, not so much difficulty in the matter; but when modern composers wrote music which required a harp of wider range, many attempts were made to increase the power of the instrument, either by increasing the number of strings, or giving the hand the power of altering the tone of each string by some mode of pressure. But nothing succeeded for this purpose until Mr. Sebastian Erard, in 1794, introduced his mechanism for a "single-action" harp, and in 1808 a further system for the "double-action." By the former of these very ingenious contrivances each string is made capable of producing two notes at the pleasure of the performer, the two having an interval of a semitone between them. By the latter system each string is made to yield *three* notes; being the natural note of the string, together with its flat and its sharp. All this is effected by means of levers: the foot of the performer presses on pedals; these pedals are connected with levers which pass up through the hollow pillar of the harp; and the upper ends of the levers are attached to delicate mechanism which alters the tension or length of the strings, thereby causing them to yield a sound higher or lower (as the case may be) than when no pedal is used. The internal mechanism of a harp thus becomes very complex, and requires great mechanical skill in its adjustment.

The *Lyre* is a representative of another instrument of the class now under consideration. Like the harp, the lyre consists of strings which are sounded by being pulled or touched with the fingers; but the number of strings is always much smaller. The instruments sketched in Figs. 1455, 1457, 1462, will illustrate the various forms given to the lyre in past times. The instruments shown in Fig. 1467, although designated lutes, are evidently the same in principle as lyres. The Hebrew lyre is believed to have consisted of ten strings, struck not by the finger, but by a quill or plectrum. The number of strings and the mode of tuning them in respect one to another seem to have been questions left open to the taste of the maker or the performer, and very little is now known of the usual custom in these respects among the early nations. In nearly all representations of ancient lyres the strings are of equal length, and this has thrown a great difficulty in the way of explaining their action; for when the strings are of equal length, difference of tone can only be produced either by varying the thickness or varying the tension; and it is not now known which plan was adopted.

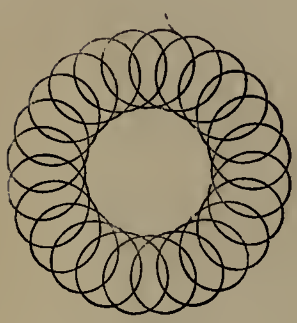
The harp, as we have seen, used formerly to yield only one note to one string, in the same manner as the ancient lyres; but, as altered by modern improvements, it can be made to yield three notes from one string. Before proceeding to notice other instruments in which many more than three can be produced from each string, it may be well to refer to another small class of instruments belonging to the simpler of these forms.

Among the Egyptians there are in use, as in England, stringed instruments of various kinds. One belonging to the class now under consideration—viz., those played without keys and without a bow,—is called the *Ḳánoon*, and is a kind of Dulcimer. It is about forty inches long by sixteen broad and two in depth. It is made of many varieties of wood, combined together in a fanciful way. It has strings stretched from end to end varying in length like those of a harp; these are fastened permanently at one end, and are wound round pegs at the other to any desired degree of tension; there is a bridge for the strings to pass over, and holes in the bed of the instrument to assist the vibration of the air within. These strings, of which there are three to each note, are made of lamb's gut. In playing the instrument the performer places it on his lap, as he sits on the ground (Fig. 1461), and touches the strings with small thin bits of buffalo's horn, called "ree'sheh," equivalent to the ancient "plectra." Each plectrum is attached to the forefinger by means of a ring, so as to hold it firm. In Fig. 1468 the various parts of the instrument are shown detached, such as the face or upper surface, the profile, the tuning-key, the plectrum, the ring for retaining it,


1485.


1483.—Observatory of Oranienberg; built by Tycho Brahé in 1576.


1487.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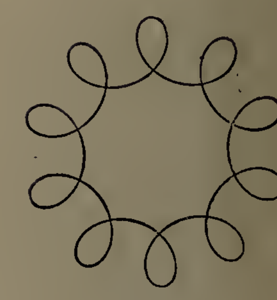
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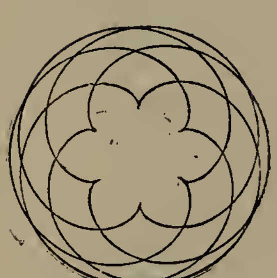
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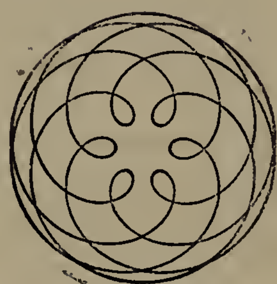
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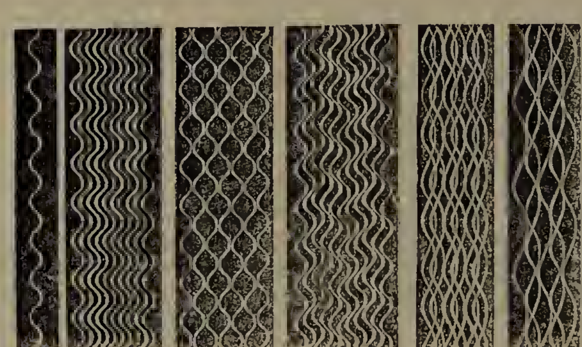
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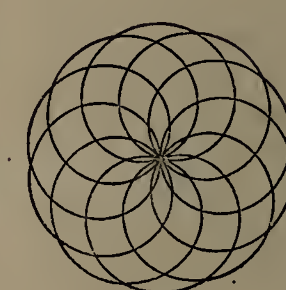
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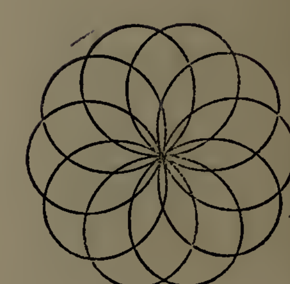
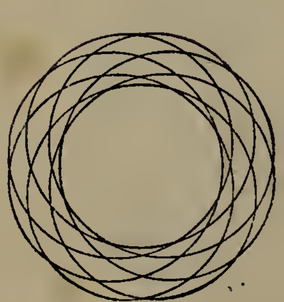
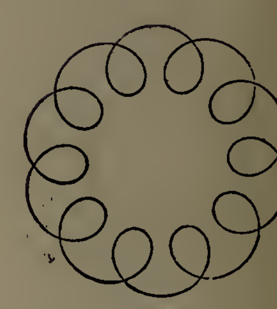

1493.

1485 to 1501.—Various Figures produced bv he Geometric Turning-Lathe


1494.


1484.—Observatory of Delhi; built by Rajah Jeysing in 1710.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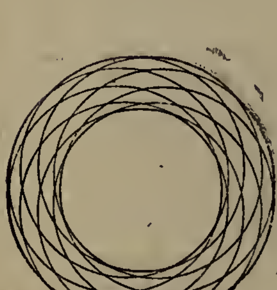
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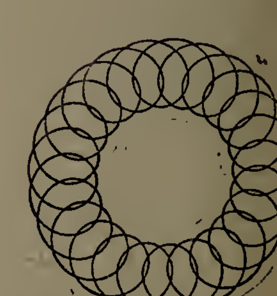
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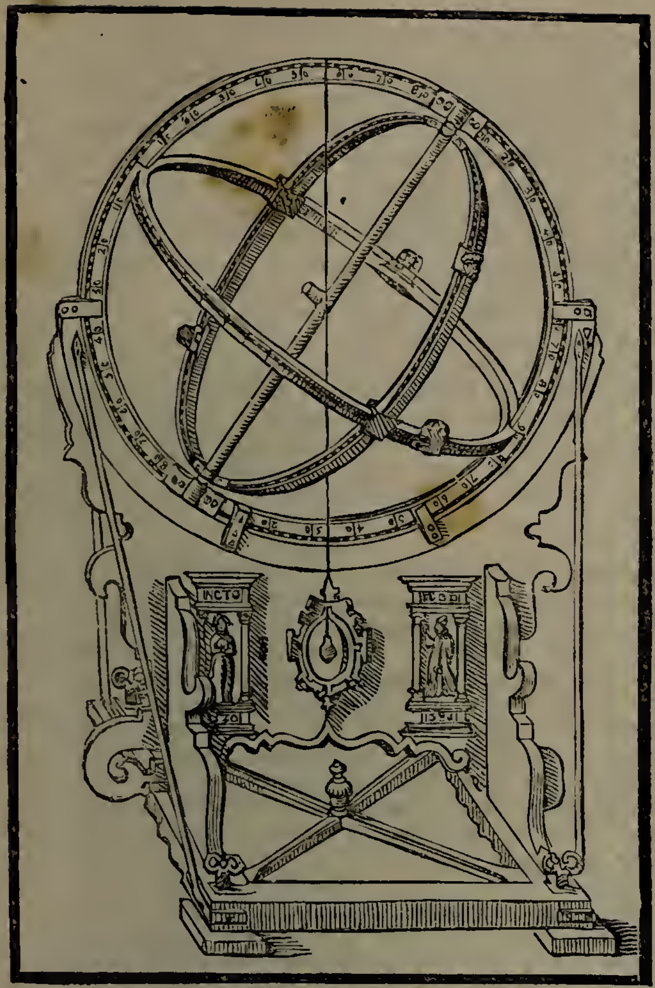
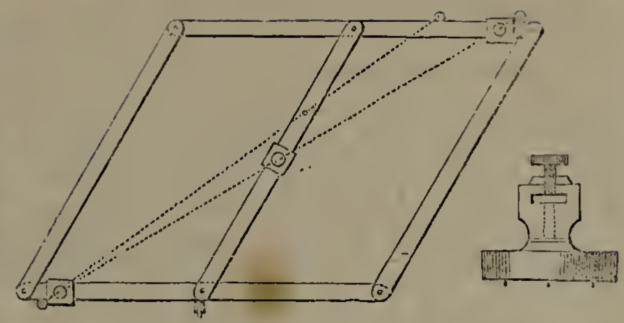
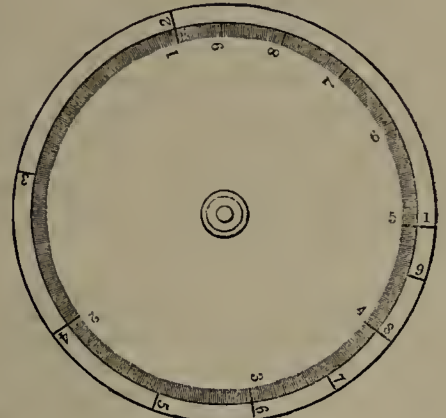


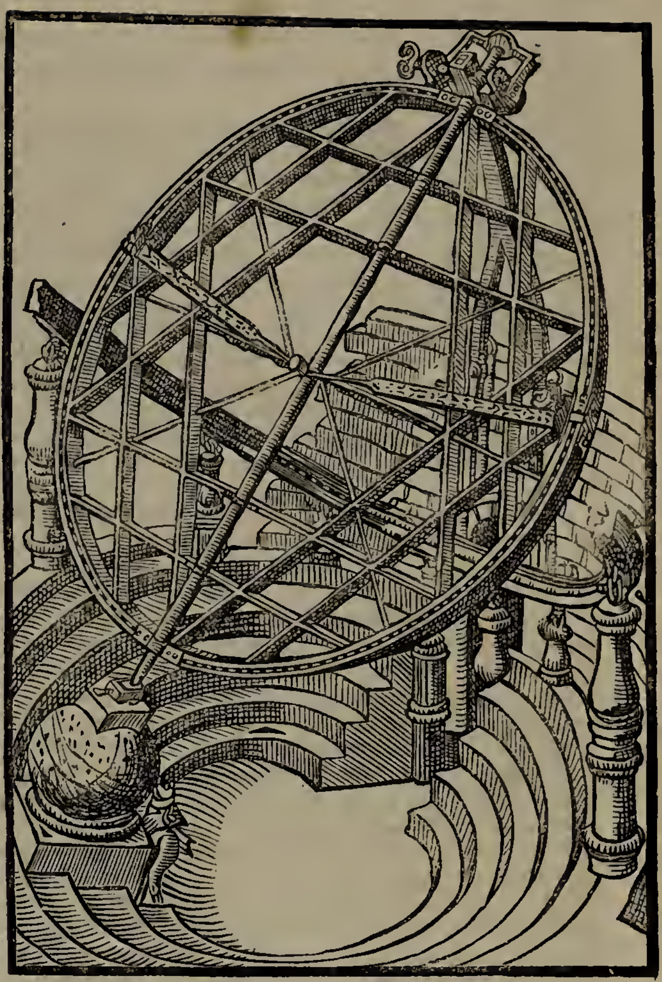
1502.—Ancient Astrolabe.



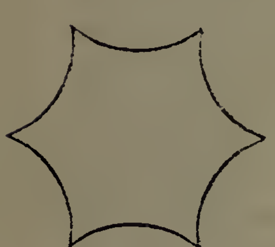
1504.—Pantograph, for copying Designs.



1505.—Circular Sliding-Rule.



1503.—Ancient Astrolabe.



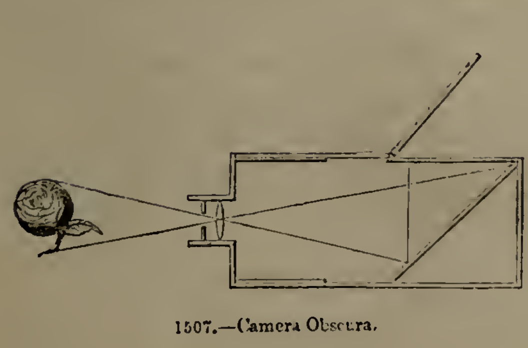
1498.

1499.

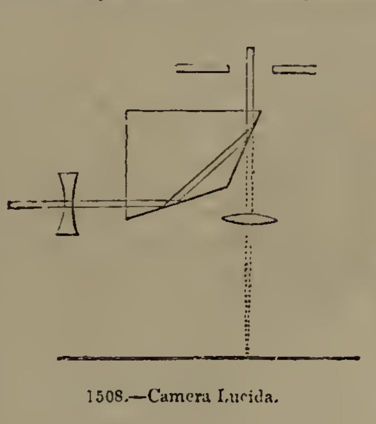
1506.—Observatory of Greenwich; built by Charles II.

1500.

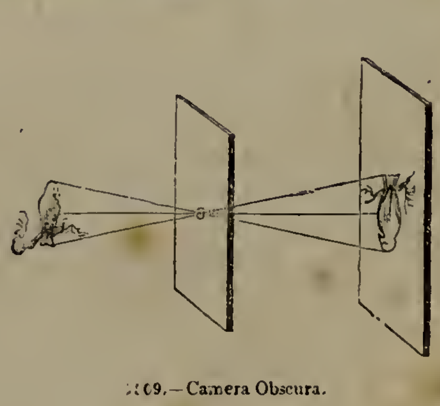
1501.



1507.—Camera Obscura.



1508.—Camera Lucida.



1509.—Camera Obscura.

and the two hands with the plectra properly attached to them.

The *Dulcimer*, alluded to in the last paragraph, and the ancient *Psaltery*, were instruments of which examples are but rarely seen at the present day. Dr. Burney describes the dulcimer as having been an instrument of a triangular form, having about fifty wire strings resting on a bridge at each end; the shortest wire being about eighteen inches in length, and the longest about thirty-six. The instrument was laid out flat before the performer, who played on it by striking the strings with two small rods, sticks, or hammers, one held in each hand; the force of the stroke being varied according to the loudness of the tone required. The psaltery differed from the dulcimer in being smaller, in having fewer strings, and in being four-sided instead of triangular.

In the above-described instruments the finger elicits the tones by striking or touching the strings, but does not regulate the musical *pitch* of the tones produced. This latter effect, however, is produced by instruments of the guitar kind, having a finger-board on which the fingers of the left hand can press on the strings, thereby modifying the tone produced. Such was the case in the *Lute* of former days, which was a favourite instrument from about the fourteenth to the seventeenth centuries. This instrument consisted of the "table," the "body," the "finger-board," and the "head." The "table" was a flat broad surface of wood, somewhat oval in form, and having an opening near the middle to facilitate the emission of sound. Attached to this table at the edges was the "body," which consisted of a hollow wooden case, intended to give resonance to the tones of the instrument. The "finger-board" was a long neck, provided with little ridges or frets, so arranged that, by pressing down the strings on these frets by means of the fingers, the effective or vibrating lengths of the strings might be adjusted so as to produce the regular tones and semitones. The "head" was the end of the instrument, and was provided with screws or pegs which afforded the means of tightening and slackening the strings so as to put the instrument in tune.

The number of strings in these lutes was not constant. Almost every number from ten to twenty-four was adopted, according to the taste of the performer. But the musical range at his service was only half of that here indicated; for there were two strings to each note. There was another variety called the *Theorbo*, or *Arch-lute* (Fig. 1464), which was larger than the common lute: it had two distinct heads, one for fastening the upper or treble strings, and one for the bass strings. The great number of strings in these instruments and the frequent "tuning" which they required led to their gradual abandonment.

The modern Egyptians have an instrument differing in no essential particulars from the lute. Mr. Lane states that it is called the "'*Oo'd.*" It is rather more than two feet in length, and is composed principally of deal with ornamental appendages of ebony. It has seven double strings: two to each note, made, like those of the "Cka'noon," of lamb's gut. The tuning of the chords is conducted on a very different arrangement from those of European guitars; for the notions of the Egyptians with respect to harmony and melody do not quite correspond with ours. The strings are struck with a plectrum formed of a slip of vulture's feather. The manner of playing is shown in Fig. 1454.

It seems probable that some such instrument as this led to the *Guitar* of modern Europe. The introduction of the guitar has been attributed to the Moors, by whom it was established in Spain and Portugal; the use of this instrument extended from Spain to Italy; from thence to France, and afterwards to England. The advantage of the guitar over the lute is, that the strings being much fewer, the tuning is not rendered so irksome. The early form of guitar had six wire strings, two of which were single, and the other four double, that is, pairs in unison, like the lute; there were thus ten strings, producing, however, the effect of only six, in regard to variations of pitch. In the modern or "Spanish" guitar there are no double strings. All the strings, six in number, have a particular thickness and quality, and there are no duplicates. Unlike the lute, the guitar is flat on both sides; but in the general mode of fixing and stretching the strings, the two instruments are pretty much alike. The strings are struck with the fingers, and not with a plectrum or quill.

The *Mandolin*, another instrument of this kind, is midway in structure between a guitar and a violin. The strings are four in number, or rather there are four double strings; the two of each pair being tuned in unison, and the four pairs being tuned like those of the violin. The strings are struck with a small quill. This instrument used to be much admired by the Italians, and is occasionally heard in our own streets; but it is very little used in modern times.

Stringed Instruments, played with a Bow.

There is yet another class of stringed instruments, comprising those which are played with a *bow* or stretched cluster of horse-hairs. Although in respect to domestic music the pianoforte takes the lead above all others, the violin (which is the general representative of the class now under consideration) is deemed the most valuable in an orchestra, from the great facility with which it can accommodate itself to every kind of music, and to every shade of intonation as regards musical pitch.

Although the violin is the most distinguished of its class, it is in some respects an offshoot from another instrument; as its Italian name, Violino, equivalent to a "little viol," indicates. The *Viol*, the earliest of the class, has been traced back during a period of a thousand years. It was shaped a good deal like the modern violin, and had six strings, all being played by drawing across them a bow of horse-hairs. It was of three different sizes, named after the parts which they were intended to take in concerted music—"treble," "tenor," and "bass." One of the last varieties of this instrument retained in use was the *Viol di Gamba* (Fig. 1469), or "leg-viol," so named by the Italians from the position in which it was held; its tone is said to have been rather nasal and disagreeable; and in the eighteenth century the instrument was supplanted altogether by others of more modern character.

The modern instruments of this form are of four kinds—or, if we call the dancing-master's diminutive "kit" one, five. The earliest form, which corresponded pretty nearly in size with the violin, was the *Rebec*, a three-stringed instrument played with a bow. Leaving this, however, and also the *Kit*, out of the question, the varieties may be considered as embracing the *Violin*, the *Viola*, the *Violoncello*, and the *Violone* or *Contra-Basso* or *Double-Bass*. The *Violin* has four strings made of catgut, the last or lowest of which is coated with silver wire; each string is wound round a peg at one end, and is tuned by turning this peg. The facility of adaptation is such, that with only four strings the performer can command a range of about three octaves, by pressing one or other of his fingers at various parts of the lengths of the strings. The *Viola* serves as a tenor violin, for the performance of parts midway between the treble and the bass; it is about the same size as the "tenor viol" of past times, but not shaped exactly the same; and it is furnished with four strings instead of six, two of which are bound round with silver wire. The *Violoncello*, a still larger instrument, is the successor of the "bass viol" and the "viol di gamba;" being superior to both: like the viola, it has four strings of catgut, of which the two lower are covered with silver wire. The largest of this family of musical instruments, the *Violone*, or Double Bass, is employed to give strength and dignity to the collected sounds of an orchestra; and in this respect it is much valued by composers. In England, France, and Italy, this instrument has three strings only; but some of the German makers add a fourth string.

We have had occasion to show that the modern Egyptians possess many of the different kinds of instruments which are met with in Europe; the same, at least, in respect to the general principle on which they are planned. They have in like manner stringed instruments played by a bow. One of these, a sort of double-stringed viol, is sketched in Fig. 1459. It is a singular-shaped instrument, very little calculated, as it would seem, to yield anything like a body of sound; but evidently belongs to the same class as those before noticed. Another kind (Fig. 1463) is such a rudely simple instrument, that we hardly know how it can possess value as a musical aid.

In all the instruments which have lately gone under review, one of the most notable mechanical requirements is the proper manufacture of the strings, whether of wire or of membrane. The metallic strings require the wire to be very correctly made or "drawn;" while those made of membrane and afterwards coated with silver wire, require this wire to be wound spirally by a machine made on purpose. But the membranous or "cat-gut" strings (as they are erroneously called) are the most important. These are made from an internal membrane of the sheep, and require a very careful preparation to fit them for the purposes to which they are applied.

The shape of a violin, in respect to the main portion of the woodwork, is a very curious matter; since no one seems able to show why the particular form adopted should be better than any other form, nor even that it *is* better. Makers of these instruments, century after century, and in almost every country in Europe, continue to adopt the same general form, without any precise determination of the advantages resulting therefrom. Some years ago a course of experiments was conducted by a French philosopher, M. Savart, with a view to arrive at something like definite ideas on this matter. He directed his attention to several different points, all bearing in various ways on the object in view. One was, to determine whether the curved undulating form of the surface was necessary to the beauty of the tones produced; another was, to find out whether the bridge answered any other purpose besides that of supporting the strings; a third, to discover what was the particular office filled by the little peg of wood called the "sounding-post," or "soul," of the violin; another, to see whether there was any particular virtue in the *f*-like form given to the two holes in the surface of a violin; a fifth, to discover whether the sides of a violin are made so tortuous for facility of playing, or for any improvement in the sounds produced. All these points he investigated; and having arrived at results which he deemed tolerably conclusive, he made a violin with his own hands, on principles differing considerably from those usually adopted. This instrument was examined by several persons, and tested with a fine violin of the usual kind; and in a Report which a Commission made on this subject, the new violin was said to be better in nearly every desirable quality than the old one.—We are not aware that any definite change has followed from these experiments, in respect to the mode of manufacturing violins; but it seems reasonable to think that investigations conducted in such a spirit as this are just the kind from which valuable results may one day be obtained. The violins made by Amati, and Steiner, and Stradivarius in past days, were so fine, that modern makers try to imitate them as much as possible; and in practical matters such a course is a safe one; still it is not less desirable to find out, by actual experiment, which of the particular features are essential to the object in view, and which are only accidental or matters of fashion.

Instruments of Percussion.

The last class of musical instruments to which we shall refer is that which includes the instruments of percussion; and of these very little need be said.

The *Drum*, as is well known, derives its action from two pieces of parchment stretched over the open ends of a cylinder. When one of these parchment heads is struck, it vibrates, more or less rapidly, according as the tension is great or small; and this vibration, together with that of the mass of air within the drum, gives origin to the sound. The parchment is stretched to any degree at pleasure by small contrivances round the edge. The *Kettle-Drum* differs from the common kind in being a hemisphere instead of a cylinder, and having one parchment instead of two. The *Tambourine* is a cylinder, or rather a hoop, with only one parchment, and without any mass of included air. The performance on this latter instrument includes something more than mere "drumming," since there are various kinds of sounds produced by the peculiar way in which the fingers and hand are applied to the parchment. The tambourine is a favourite instrument in many Oriental nations, by whom great diversity of appearance is given to it (Fig. 1465).

The *Cymbals*, the *Triangle*, the *Gong*, the group of *Bells*—all are examples of the elasticity of metals, and of the sonorous qualities resulting from this elasticity, when vibrations are excited. The chief manufacturing details involved in the production of such instruments relate to the proper choice of metal, and the annealing and tempering to which it is to be subjected.

It is not pretended for a moment that the above rapid sketch includes *all* the varieties of musical instruments; but it certainly does include the principal among them, sufficient to illustrate the larger groups of mechanical contrivances by which the musical effects are brought about. The vibration of a stretched wire of metal or a stretched cord of membrane, by the fingers, by a bow, by a plectrum, by a hammer, or by a lever and keys; the vibration of a thin reed or tongue by breath from the mouth or by wind from a bellows; the vibration of a column of air in a long tube by similar means; the vibration of a film of parchment or a thin piece of metal by concussion—these are the modes of action whereby musical effects are produced; and it is not difficult to trace the way in which the various arts of working in wood and in metal are brought to bear on this object.

The contents of the present Chapter will have shown—what indeed can hardly need to be proved—that the subjects of Writing, of Literature, and of the practice of Music, are capable of being viewed irrespective of the various sciences and mental qualities on which they depend: the object being here to show how far Art, in its productive or manufacturing sense, is contributory to the attainment of the end in view. No one can fail to see that this collateral aid is both large and amount and ingenious in kind.

CHAPTER XI.

THE ARTS CONTRIBUTORY TO SCIENCE.

The Chapter at which we are now arrived—the concluding one of this volume—may conveniently be devoted to a brief notice of some of the aids which the productive arts render to the sciences.

There is observable, throughout the various departments of study or knowledge, a close and intimate relation between theory and practice—between meditation and action—between the discovery of a law in nature and the application of that law to practical purposes—in other words, between Science and Art. It is not always that this relation is duly considered; for the adherents to one of these two departments sometimes depreciate those of the other. The theorist occasionally looks down upon the man who only possesses "common sense," as a very mechanical and inferior sort of person; while the practical man not unfrequently regards philosophers as beings who live in the clouds—almost useless to society, and unfitted to rub their way through the bustle of everyday life.

Both parties are wrong; and the error arises from a sort of near-sightedness of the mind, which limits the conceptions within a very narrow circle. The best way to prove this is to take up any one distinct subject, and see how the *Thinkers* would get on without the *Doers*, or *vice versâ*. Take Navigation, for instance. The philosopher finds out the relation which the earth bears to the heavenly bodies—the mutual bearings which the Equator, the Ecliptic, and the Meridians have to each other; the mathematical laws of Spherical Geometry, and the application of these to the measurement of distances on the earth's surface; the tendency of a magnetized piece of metal to point pretty nearly in one constant direction; and others of a similar kind. But his thinkings and demonstrations would do little towards conveying him to America or to the Continent without the services of the practical man or the instrument-maker. The latter attends to the qualities of various kinds of wood, metal, and glass; the working up of these into tubes, axes, pivots, graduated scales, lenses, reflectors, magnets, and numberless other pieces of apparatus; and the establishment of such a completeness, both in principle and in details, as will furnish the means of determining, from the data supplied by the philosopher, the exact position of a ship on the broad ocean, when nothing but water and sky is visible. It would be nonsense to say that either party could do without the services of the other, and useless to attempt any determination of the relative value of the two: where both are indispensable, a contest for chieftainship may well be dispensed with.

In all the various subjects of study and investigation, a similar interchange of services is observable. In some cases the establishment of scientific principles has far outrun application in practice; while in others the practical man has to do much before he obtains aid from science. In most instances, however, the exchange of services is renewed over and over again. Science discovers that glass and similar transparent bodies are capable of focalizing light, when they are properly shaped; Art, thereupon, fashions the lenses for this purpose, and thereby enables Science to discover new truths in Astronomy or in Optics; these new truths, again, suggest to Art the means of making instruments powerful enough to explore the depths of space, or delicate enough to show myriads of animalcula within a small speck in space. Thus the two go on: each gaining extent and value, by giving extent and value to the other.

A few among the examples of Art as contributory to Science may now engage our attention.

MATHEMATICAL INSTRUMENTS.

The common expression, "mathematical" instruments, is not strictly a correct one, since it does not always apply adequately to the pieces of mechanism so named: it is too comprehensive for some, and too limited for others. In a general way, however, it relates to pieces of wood or metal, calculated to measure some of the numerous varieties of magnitude or quantity, or to aid other instruments in bringing about such measurements. A considerable number of these may be grouped under the heading of

Instruments for Drawing.

The means provided for drawing straight or curved lines—in the fine arts, in some of the professions, and in many of the mechanical arts—are very ingenious, and call for much skill in the arts of working in wood and metal.

If we look at Fig. 1470, and consider that these are representations of drawing-instruments found at Pompeii, we shall see that the same ideas were entertained in past times as at present, concerning the use of the compasses, the graduated rule, and the plummet. Most of the other wood-cuts on the same page (p. 365) relate to some kinds or other of drawing, or measuring, or reckoning: some of which deserve a few words of comment.

The "sliding-rule" (Fig. 1471) is an extension of the common rule or measure used by carpenters and others; it consists, in fact, of two rules, one sliding within a groove of the other. Both are so graduated as to furnish the means of performing addition, multiplication, and other arithmetical processes; by adjusting each of the two portions according to given relations, and then observing the joint action of the two. The varieties of sliding-rule are many. One, for instance, takes a circular form (Fig. 1505): in which there are two rings, graduated differently, sliding one within the other.

The sliding-rule may be regarded either as an aid to drawing or an aid to calculating; for it is used as both. Mechanical aids to calculation, strictly as such, are however not wanting. One aid, for instance, is the "Abacus," or calculating-frame (Fig. 1474). Such an instrument, in one or other of many different forms, has been used in several countries. The Chinese have an Abacus called "Schwanpan," consisting of a frame having wires stretched across it, and five beads for each wire; each wire has a particular value, and each bead also a particular value; and by the relative places of the two the Chinese are said to be able to add up sums and quantities with great rapidity. The Greeks and Romans occasionally used some kind of abacus; and the Russians are said to do so even at the present time. In our cut, the right-hand wire stands for units, the next for tens, the next for hundreds, the next for thousands, and so on; while the beads in each group represent the number of these to be taken. Thus, the lower group of beads represents the number 57,048; and any number from 1 to one million could be similarly represented.

The pieces of wood called "Napier's rods," or sometimes "Napier's bones," are a curious means of aiding calculation. There is, in the first place, a straight rod of wood (Fig. 1478), having a series of numbers on it; several such are put side by side, in the manner shown in Fig. 1477; and by having each rod numbered in a particular manner, and the various rods ranged in a particular order, sums in multiplication are capable of being worked with much quickness. The "Reckoning-board," sketched in Fig. 1481, is one of the results of the benevolent attempts to teach the blind to read, to write, and to calculate, alluded to in page 350. The board now under consideration is about sixteen inches long by twelve wide, having a number of five-sided holes in it; there are pins to fit these holes, having a projection at one end at an angle, and another projection at the other end in the middle of one side. These projections, and the place which each projection is made to occupy in the holes, furnish symbols for the nine numerals, which can easily be felt by the fingers of the blind students, and thus made the elements for calculation. The curious "Cubical Calendar," shown in Fig. 1482, though hardly to be called a medium for calculation, is still an example of a tangible form being given to that which has resulted from calculation.

All such drawing-instruments as "compasses" are simple enough to be understood by every one; but there are others which combine a writing or drawing instrument, superadded to one for determining curved or geometrical figures, very complex in their arrangements. The "Geometric pen," for instance (Fig. 1473), is an instrument having three curved bars or supporters, from the centre or junction of which is suspended a system of small and delicate mechanism, so contrived as to enable a pencil or pen to describe curves of almost any required kind. The eight small figures sketched in Fig. 1475, for instance, are examples of the results produced by different arrangements of the apparatus.

The "Pantograph" is another among the many instruments employed in drawing, or transferring a design from one paper to another. The mechanism connected with it (Figs. 1472, 1504) is such as to enable the draftsman to copy a drawing on a scale either larger or smaller than the original. Many varieties of lathe, too, are so ingeniously arranged that they afford the means of producing curves of great beauty and variety. The seventeen small specimens, for instance, shown in Figs. 1485 to 1501, were produced by the action of a lathe of this kind: the curves themselves were intended to illustrate a particular class of mathematical figures; but they will also serve as favourable examples of the power of the instrument which produced them.

The means of drawing various kinds of mathematical figures by mechanical instruments are afforded by numerous other examples; of which it will suffice to adduce the two illustrated in Figs. 1479, 1480. These are contrivances for producing an ellipse or oval: in the one case by a string connected with two foci or fixed points; and in the other by a bar sliding in two grooves at right angles one with another.

The instruments for taking profile likenesses of the face often comprise some such arrangement as the pantograph, and at other times something analogous to the "proportional compasses." The "Silhouette" (Fig. 1476) is a remarkable instrument of this class. It consists of a horizontal lever, having a pencil at one end and a point at the other; with a fulcrum or point between the two, but nearer the pencil than the pointed end. The point passes carefully over the features of the face; while the pencil at the other end traces lines of corresponding form, but smaller in size, on a piece of paper adjusted to a board or tablet. There are many minor pieces of mechanism, intended to facilitate the correct copying, at one end of the machine, of the object placed at the other.

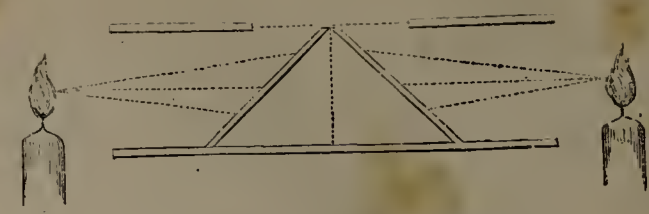
Graduation of Instruments.

No part of the labours connected with the construction of Philosophical Instruments is more delicate than that of "graduation," or marking the degrees on circles, sextants, quadrants, verniers, &c. It might seem a very easy matter to divide a circle into any required number of equal parts, and to scratch a mere line at each of these divisions; but in practice, where the scrupulous accuracy of astronomy requires minute attention to every point, the task is surrounded with extraordinary difficulties. Where the graduated lines are a tenth of an inch, for instance, apart, the requirements of the instrument do not call for extreme accuracy; but where they are so close together that a microscope is required to detect their separation, the difficulties thicken at every step.

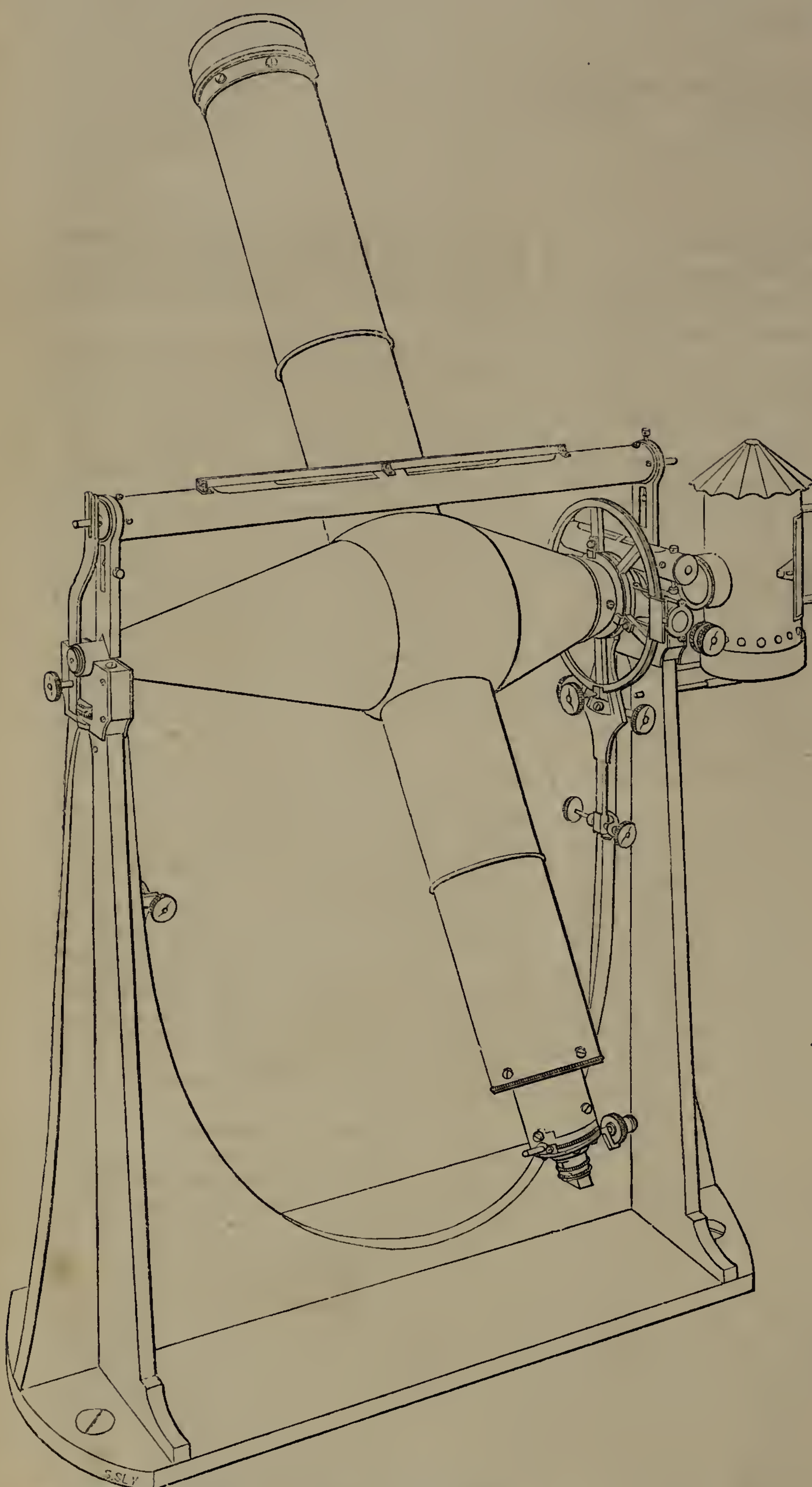
A common box-wood rule or scale, sold perhaps for a shilling, requires graduation as well as the costliest instrument in an observatory; but there are different modes of effecting this graduation, as well as different degrees of care in each mode. The drawing-instruments, such as we have lately spoken of, when they require any graduation at all, are usually treated in the following manner:—There is an original pattern, very carefully graduated, which is fitted to guide the hand in graduating the scales or rules for sale. This pattern and the scale are placed side by side; a straight edge, with a shoulder at right angles, like a carpenter's square, is made to slide along the pattern, stopping at each division, when a corresponding stroke is cut by the dividing-knife on the scale. If the scale is to be a curved one instead of straight, such as the instrument called a "protractor," the straight edge is made to turn on the centre of a divided circle, and the divisions of this circle are copied on the scale.

Until the time of Ramsden, most theodolites and other instruments were graduated in some such way as this. But the advancement of astronomical science required increased accuracy in this respect; and Ramsden rendered essential service by the invention of a "dividing-engine," in which the threads of a screw, moved

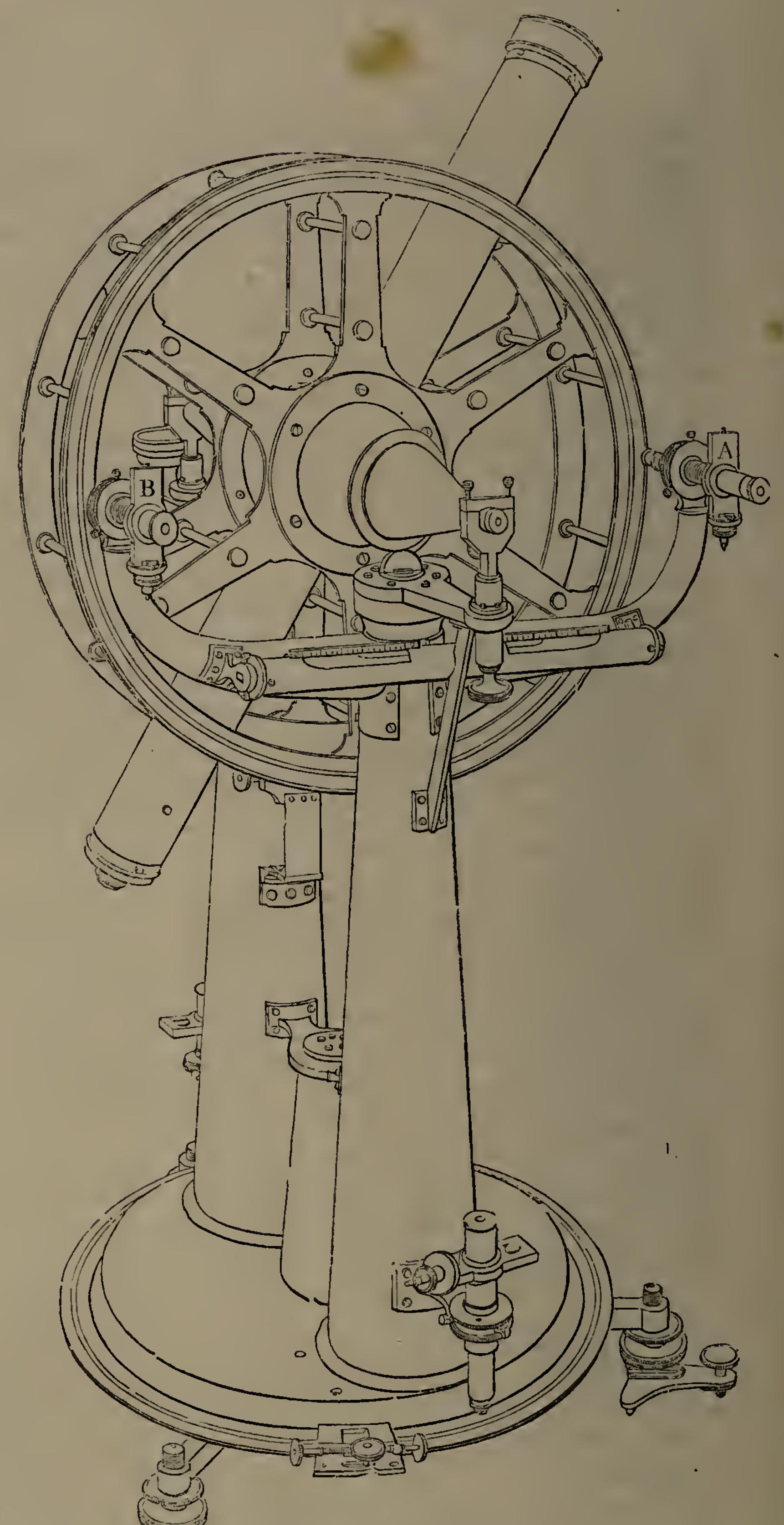
1510.—Various forms of Spectacles.



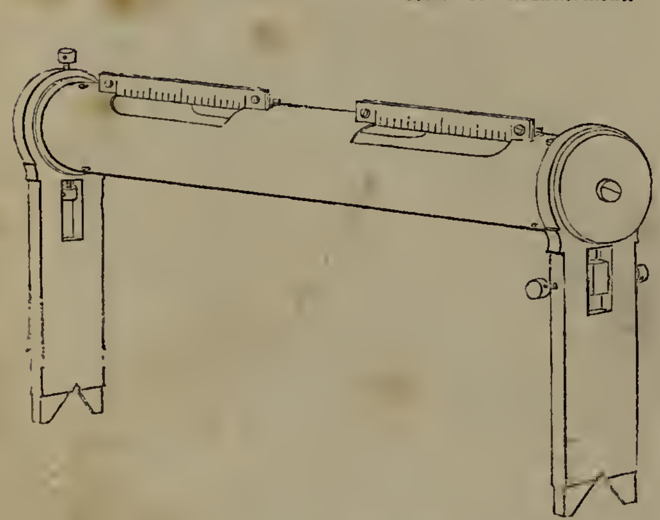
1511.—Photometer, or Light-Measurer.



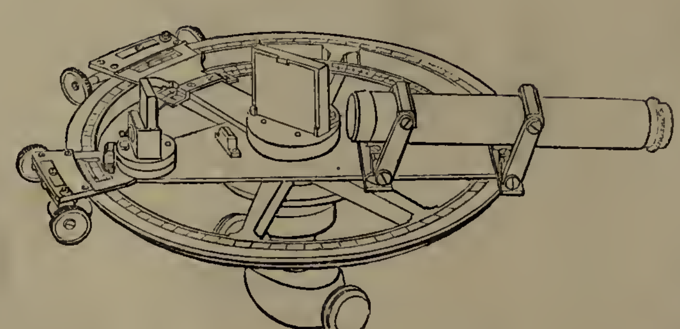
1512.—Transit Instrument.



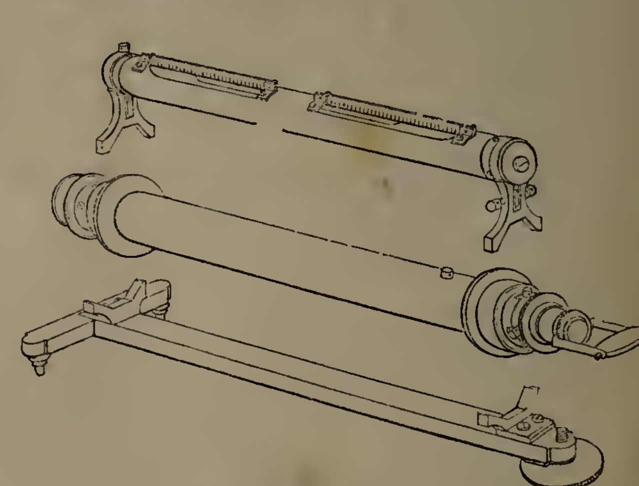
1513.—Altitude and Azimuth Circle.



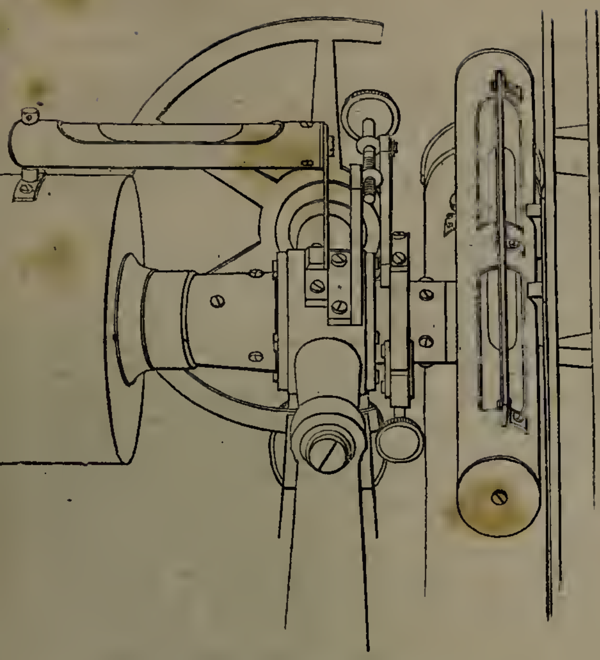
1514.—Detached or Transit Level.



1515.—Borda's Repeating Circle.

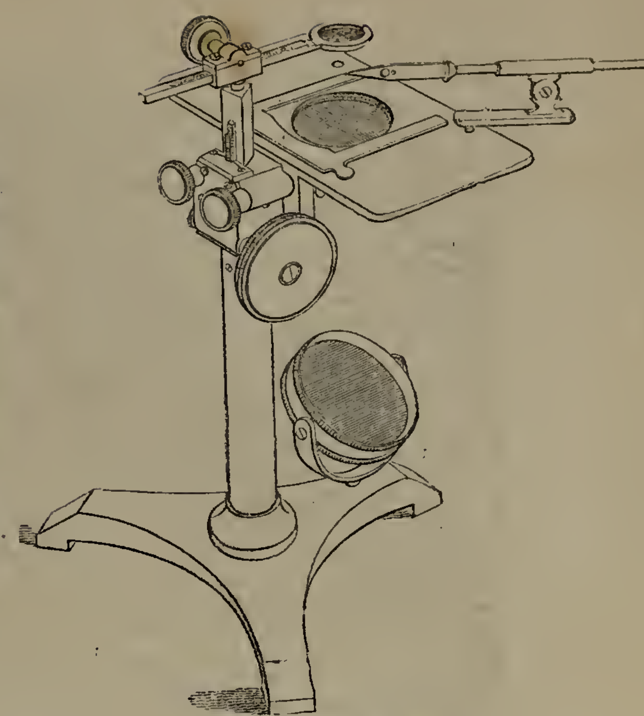


1516.—Level Collimator.

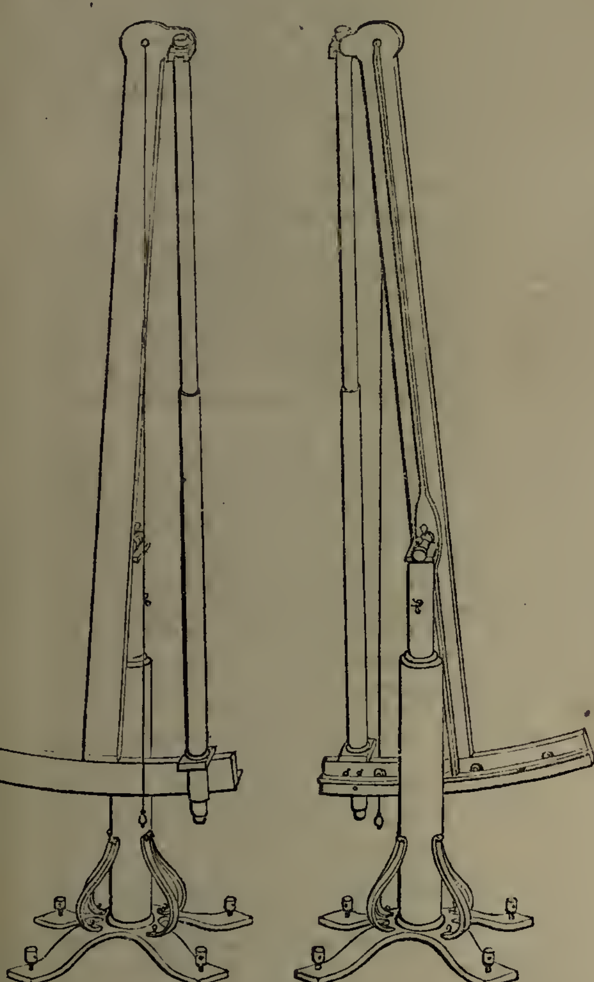


1517.—Back of Borda's Repeating Circle.

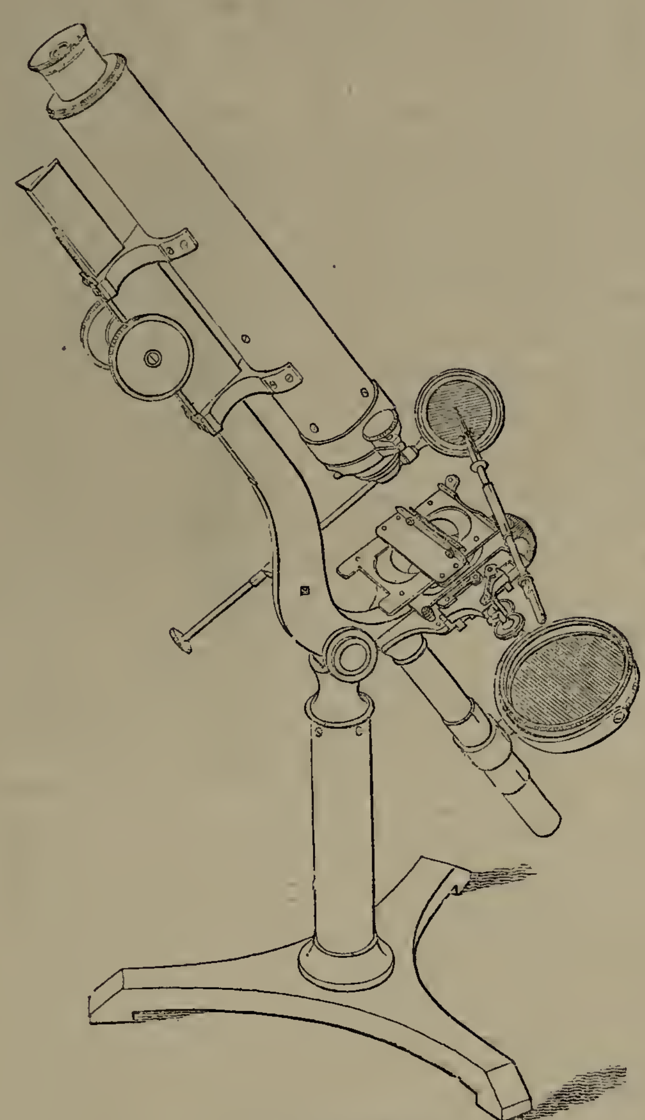
1518.—Street Telescope.



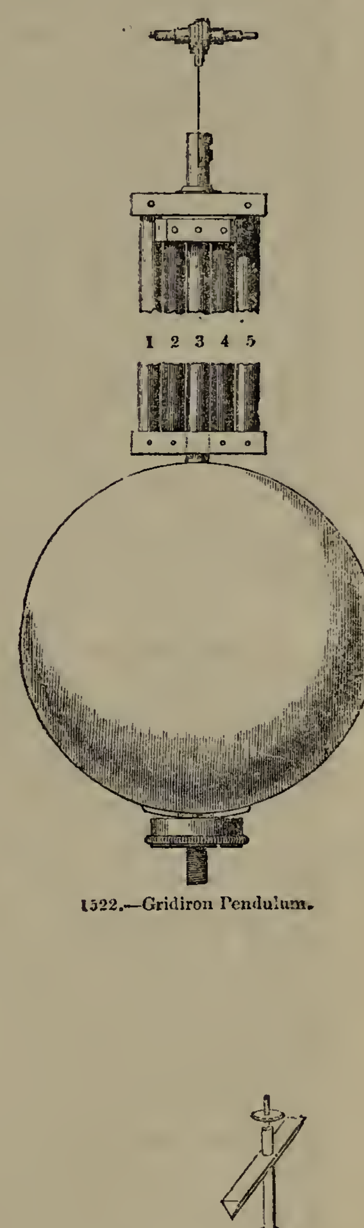
1519.—Simple Microscope.



1520.—Zenith Sector.

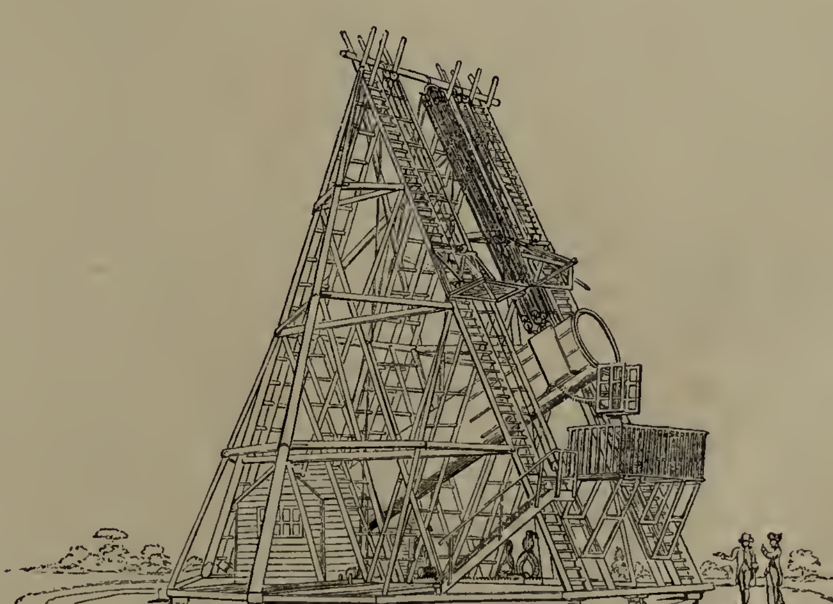


1521.—Compound Microscope.

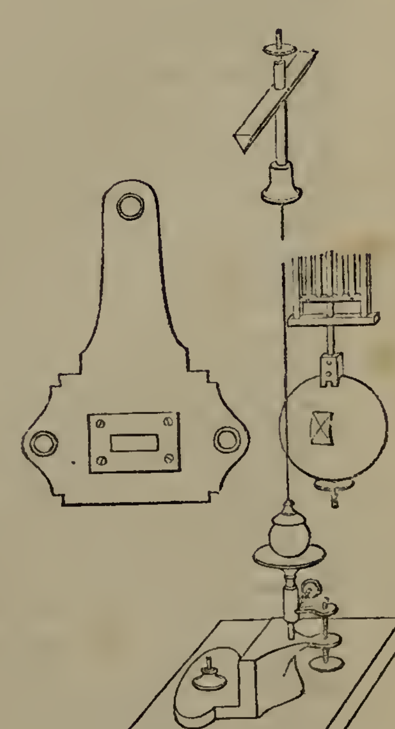


1522.—Gridiron Pendulum.

1523.—Kater's and Borda's Pendulums.



1524.—The late Sir W. Herschel's great telescope at Slough.



1525.—Borda's Pendulum apparatus.

by a treadle, enabled the instrument to be divided to be moved through an extremely small space, between each two operations of the cutting edge. Ramsden was employed by Dollond and others as a "divider" or graduater of instruments; and his skill in this art soon brought him into note. In a memoir of him, in the 'Penny Cyclopædia,' it is stated that "His occupation afforded him frequent opportunities of observing the defective construction of the sextant then in use, the indications of which, as had been pointed out by Lalande, could not be relied on within five minutes of a degree, and might therefore leave a doubt in the determination of the longitude amounting to fifty nautical leagues. The improvements introduced by Ramsden are said by Piazzi to have reduced the limits of error to thirty seconds. This circumstance, added to the cheapness of his instruments, which were sold for about two-thirds the price charged by other makers, produced a demand which, even with the assistance of numerous hands, he found difficulty in supplying. In his workshops, the principal of the division of labour was carried out to a considerable extent, and a proportionate dexterity was acquired by the workmen; but it is asserted that in none of these, even the most subordinate, and least of all in the higher departments, did the skill of the workman surpass that of Ramsden himself. His attention was incessantly directed to new improvements and further simplification, the result of which was the invention of a dividing-machine. The date of this invention is prior to the year 1766. At first it had many imperfections; but by repeated efforts of ingenuity throughout a period of ten years, they were successfully removed. In 1777 it was brought under the notice of the Commissioners of the Board of Longitude, by Dr. Shepherd, and by them a premium of 615*l.* was paid to the author, upon his engaging to divide sextants at six and octants at three shillings, for other mathematical-instrument makers. A description of the machine was immediately published by order of the Board, under the supervision of Dr. Maskelyne, and was shortly after translated into French by Lalande. A duplicate of the machine itself is said to have been purchased by the president, Bochard de Saron, and introduced into France concealed in the support of a table made for that purpose. As early as 1788, no less than 983 sextants and octants had issued from Ramsden's workshop."

After Ramsden's time many other instrument-makers took up this difficult art, and introduced further improvements in it from time to time. Mr. Troughton, in particular, brought this department to the highest pitch of excellence which it has anywhere attained.

Astronomical Instruments.

The graduation just alluded to is only one among the many points which the makers of such instruments have to attend to. The fashioning of the various pieces of metal, and the adjustment with such care and delicacy as to produce the desired results, call for a combination of many different kinds of skill.

Let us glance, for example, at the instruments depicted from p. 372 to p. 376. We find there many among the objects to which the attention of our great astronomers has been directed, and for which they are indebted to the skill of our Dollonds, Troughtons, and artists of the same stamp. By far the larger number of these are intended (besides the optical effects resulting from the use of lenses) to determine the altitude of a heavenly body above the horizon, the direction of a body with respect to the meridian, or both of these combined. The transit instrument, the altitude and azimuth circle, the transit level, the reflecting circle, the level collimator, the repeating circle, the zenith sector, the equatorial, the mural circle, the theodolite, the sextant (Figs. 1512, 1513, 1514, 1515, 1516, 1517, 1520, 1526, 1527, 1530, 1533, 1538)—all have some such object in view, either in relation to celestial or terrestrial bodies. Most of them comprise a telescope as the chief feature; the other portions of the instrument being devoted to the means of measuring accurately the position of objects viewed by it.

There are numerous instruments which, though not immediately astronomical in their application, have an intimate relation to the requirements of that science, by aiding in the determination of points essential to correct observation. Such, for instance, are the various kinds of pendulums (Figs. 1522, 1523, 1525, 1532) employed, sometimes to measure small and equal portions of time, and on other occasions to determine the attractive force of gravitation.

In the manufacture of such instruments the expansibility of metals under the influence of heat is one of the difficulties which have to be contended against; and another is the fitness of different metals to work against or with each other. The form and general appearance, too, of the instruments are matters not neglected; for there is much neatness and compactness—even elegance—in the general arrangement of the parts. Some of the earlier astronomical instruments, such as the astrolabes, are represented in old engravings as very rough specimens of workmanship, compared with those of modern times. The two sketched in Figs. 1502, 1503, for example, are copied from old representations.

OPTICAL INSTRUMENTS AND OBSERVATORIES.

The instruments spoken of in the above paragraphs were there considered in respect to the mechanical arrangements of the brass and other metal of which they were constructed; but the *optical* features require a little distinct notice.

A piece of glass may be said to have been the mainspring of all the great optical discoveries as connected with astronomy. It is so beautifully clear and transparent; it is capable of being worked into such a variety of forms; its composition is so well known; and it has been used by European nations for so many centuries—that it transcends all other substances in the facilities which it affords for optical research.

Invention of Telescopes and Microscopes.

The invention of the telescope illustrates in a remarkable way the optical power of glass when curved in a particular manner. It is known to all near-sighted persons that a *concave* lens renders objects smaller, but more distinct than they appear without the lens; while off-sighted persons have equal means of determining that a *convex* lens renders objects, to them, larger and clearer than they appear without such aid. These facts were known many centuries ago; but the more comprehensive fact, that two lenses, either both convex, or one convex and one concave, when placed at a certain distance apart, give the power of magnifying the apparent dimensions of objects to a great extent, was reserved for Galileo to prove, though many persons had previously some indistinct idea of it. One of these persons, Thomas Digges, writing in 1591, says:—"My father, by his continuall painfull practises, assisted with demonstrations mathematicall, was able, and sundry times hath by proportionall glasses, duly situate in convenient angles, not only discovered things farre off, read letters, numbered pieces of money, with the verye coyne and superscription thereof, cast by some of his freends of purpose, upon dounes in open fields; but also, seven miles off, declared what hath been donne at that instant in private places." Baptista Porta and many other persons have had their claims to a similar honour discussed. A Dutch maker of spectacles, named Jansen, seems to have been the first whose telescopes became matter of talk in his own day; for it appears that (probably by accident) he had placed two lenses in such a position that, on looking through both, objects appeared nearer than they really were. Whether Galileo saw one of these telescopes, or was led to investigate the matter by private study and experiment (and this has been a subject for fierce controversy), it is certain that he was the man to give to this instrument a degree of favour and importance which it has never since lost.

Galileo's first telescope was formed like a modern opera-glass, with one convex and one concave lens. Its performance, though of the humblest order in comparison with modern instruments, made an extraordinary stir at the time. In the Life of Galileo ('Library of Useful Knowledge') it is stated:—"As soon as Galileo's first telescope was completed, he returned with it to Venice; and the extraordinary sensation which it excited tends also strongly to refute Fuccarius's assertion that the Dutch glass was already known there. During more than a month, Galileo's whole time was employed in exhibiting his instrument to the principal inhabitants of Venice, who thronged to his house to satisfy themselves of the truth of the wonderful stories in circulation; and at the end of that time the Doge, Leonardo Donati, caused it to be intimated to him that such a present would not be deemed unacceptable by the Senate. Galileo took the hint, and his complaisance was rewarded by a mandate confirming him for life in his professorship at Padua, at the same time doubling his yearly salary, which was thus made to amount to one thousand florins. It was long before the phrenzy of public curiosity abated. Sirturi describes a ludicrous violence which was done to himself when, with the first telescope which he had succeeded in making, he went up into the tower of St. Mark, at Venice, in the vain hope of being there entirely unmolested. Unluckily, he was seen by some idlers in the street: a crowd soon collected round him, who insisted on taking possession of his instrument, and, handing it one to the other, detained him there for several hours till their curiosity was satisfied, when he was allowed to return home. Hearing them also inquire eagerly at what inn he lodged, he thought it better to quit Venice early the next morning, and prosecute his observations in a less inquisitive neighbourhood. Instruments of an inferior description were soon manufactured, and vended everywhere as philosophical playthings, much in the way in which, in our own time, the kaleidoscope spread over Europe as fast as travellers could carry them. But the fabrication of a better sort was long confined, almost solely, to Galileo and those whom he immediately instructed."

Sir Isaac Newton was one of the great men who advanced this species of aid to the astronomers. About the year 1669 he commenced a course of experiments on the passage of light through pieces of glass of various forms, with a view to determine the mode of focalization, and the adaptation of different kinds of lenses to telescopes. A particular form of the instrument, named after him the "Newtonian" telescope, became established.

The same circumstances which led by slow steps to the invention of the telescope, paved the way for the microscope. The difference between making a distant object appear near, and making a small object appear large, is one rather of detail than of principle; since a small change in the relative curvatures of the lenses employed would convert one, in principle, into the other. In the early history of these instruments, not only is there a contest of opinion which of the two was inverted first, but it is not always easy to determine whether the instrument described or alluded to was one or the other. It is believed, however, that Jansen the spectacle-maker invented the microscope, about the year 1590, and that this was one of the means of turning men's minds towards the telescope. In the early years of the history of this instrument, like that of the telescope, astonishment was the prevailing feeling which it excited. An amusing story is told of a Bavarian philosopher, who, travelling in the Tyrol with one of the newly invented microscopes about him, was taken ill on the road and died. The authorities of the village took possession of his baggage, and were proceeding to perform the last duties to his body, when on examining the little glass instrument in his pocket, which chanced to contain a flea, they were struck with the greatest astonishment and terror; and the poor Bavarian, condemned by acclamation as a sorcerer, who was in the habit of dealing with mysterious agencies, was declared unworthy of Christian burial. Fortunately for his character, some bold sceptic ventured to open the instrument, and discovered the true nature of the imprisoned fiend.

Lenses and Optical Apparatus.

Since the seventeenth century, when the labours of Galileo, Newton, Gregory, and others, established the telescope and the microscope on something like a sound basis, every successive generation has added something to the completeness of the means for producing these beautiful instruments. Among those who aided in this advancement was John Dollond, the first of a family which has since become distinguished in this branch of scientific art.

Dollond was one of those who have had to struggle up to fame in spite of difficulties which would chill an ordinary mind. He was the son of a Spitalfields weaver, and was obliged himself to follow the same avocation during his early years. It is said of him ('Pursuit of Knowledge under Difficulties,' vol. ii.), that even during his boyhood, "he began to show an inclination for the mathematics, and before he was fifteen he used to amuse himself, during what little leisure he could command, in constructing sundials and solving geometrical problems, although at this time he had scarcely had an opportunity of looking into any book on these subjects. These early habits of study he continued as he grew up towards manhood; so that, notwithstanding the disadvantages under which he laboured, he had ere long accumulated a considerable store of learning on his favourite subjects of inquiry. He married early, and an increasing family forced him to make still more unremitted exertions for their support; so that, although he seems now to have become a master manufacturer, he had still less time for private study than ever. But the leisure which business deprived him of during the day, he procured for himself, as many other students have done, by stealing it from the hours usually allotted to sleep. In this manner he continued to improve himself in geometry and algebra, after which he applied himself to different branches of natural philosophy, and with especial ardour, it is recorded, to the kindred departments of astronomy and optics. But Dollond's studies were not confined at this time even to what is commonly called science. He found time to attain a competent knowledge of anatomy, to read a great deal of divinity, and even without any instructor to make himself so far master of the Greek and Latin languages, as to enable himself to translate the New Testament from the one into the other."

The two Dollonds—John, and his son Peter—advanced so rapidly in the practical study of optics, that they were enabled at length to quit their old employment of silk-weavers, and embark in the more congenial one of constructing telescopes. The elder Dollond made a discovery of a property of light, which had baffled the inquiries of Newton, Euler, and other first-rate men—a property which, when obeyed in the formation and shaping of lenses, enabled him to produce "achromatic" telescopes, that is, telescopes free from certain defects of colour which had vitiated all instruments constructed before his time.

From the days of the elder Dollond to the present time, the researches of mathematicians, of natural philosophers, and of practical opticians, have furnished the means of bringing telescopes, microscopes, and all such instruments to a state of marvellous perfection.

The lenses for the fine telescopes deposited at the various observatories have been the result of an amount of care and labour scarcely conceivable to any but astronomers. The existence of flaws, specks, or colour in the glass is so frequent, that the optician has to search among a large number of specimens before he can find one suited for his purpose; and when he has thus suited himself, a long and tedious operation is necessary before he can bring the piece of glass to a proper form. Whether it is for a telescope or a microscope, this accuracy is essentially necessary, although perhaps not in an equal degree.

There are other forms of optical instruments, too, devoted to objects not precisely analogous either to that of the telescope or the microscope. Such, for example, as the Camera Obscura (Fig. 1507). This is a box, having a convex lens at one end, and a piece of glass as a reflector placed diagonally near the other. The rays of light, proceeding from an object, pass through the lens, and after being focalized, they are reflected from the surface of the glass, and throw a picture of the object up against a piece of ground glass in the lid of the box. Even without a lens, a pin-hole in a card, carefully managed in a darkened room, would suffice to give an inverted image of an object on a screen placed in front of the hole (Fig. 1509); and when a lens is used, instead of a mere pin-hole, the effect is yet more decided. The Camera Lucida (Fig. 1508) is an ingenious contrivance, due to the late Dr. Wollaston, for forming a picture or image of an object on a flat sheet of paper, by allowing the rays of light from the object to fall through a peculiarly shaped piece of glass. The Photometer (Fig. 1511) is an instrument for measuring the intensity of the light from a flame, by the strength of the reflexion which it gives when the rays fall on an inclined piece of glass, or the relative intensities of two flames, by the relative reflexions which they yield, at equal or at unequal distances.

Most of those instruments which we lately described in respect to the metal-work and graduation belonging to them, owe a large measure of their importance and beauty to the glass lenses which they contain. As to spectacles (Fig. 1510), little may be said: those who require them, know that concave lenses are necessary for "near-sight," and convex for "off-sight;" those who do not need them may congratulate themselves on the circumstance. The transit instruments, the altitude and azimuth circle, the transit level, the reflecting circle, the collimator, the repeating circle, the equatorial, the mural circle, the zenith sector, the sextant, the theodolite—all require either a telescope as part of the fittings, or lenses analogous in character to those of the telescope. With respect to the microscope, the apparatus connected with the "simple" form of the instrument (Fig. 1519), the "compound" (Fig. 1521), and the "micrometer" mechanism (Fig. 1541) will sufficiently illustrate the complexity of these beautiful productions. In many of these instruments the use of a reflecting speculum, such as was described in the Chapter relating to Metals, is combined with that of glass lenses; and the inquiries of naturalists into the minute details of organized structure, owe a debt to these combined agencies which can hardly be appreciated.

Observatories.

Those important buildings in which the observations of astronomers are made, may perhaps be ranked among the appliances which art contributes to science. There are in most of the great cities of Europe, as well as in some of the minor towns, such buildings, in which, by an almost universal consent, astronomers are allowed to pursue in tranquillity, undisturbed by the bustle of politics or of commerce, the labours which are to bring advantage to the world and honour to themselves. Such buildings are, indeed, among those which deserve respect from all.

Some of the observatories, of which accounts have been handed down to us, have had features which took them out of the common run, and gave them an interest of their own—either for their singularity or their importance. The fantastic-looking building sketched in Fig. 1483, is a copy from an engraving of the observatory which Tycho Brahé built in Denmark in or about the year 1576. The king of Denmark gave him a small island in the Baltic for this purpose, and Tycho built there his "Oranienburg" or "Castle of the Heavens," as he termed it. This appears to have consisted of a considerable number of rooms decked out with more external finery than seems compatible with the severe nature of the studies to be carried on within. Besides this building aboveground, he had another sunk below the level of the ground, which he called "Sternburg," or "City of the Stars." In these two buildings he had about thirty astronomical instruments, larger in size and superior in accuracy to those customarily met with in his day. In these two buildings Tycho Brahé made those observations which have connected his name imperishably with the progress of astronomy.

Among the most remarkable observatories is one which was erected at Delhi in the early part of the last century. It is remarkable both as having belonged to a people (the Hindoos) who do not customarily find a place in our books of science, and as being very curiously built. The Hindoos have always paid considerable attention to some among the sciences, and to astronomy in particular; and it seems to have been a love for this science on the part of one particular individual that led to the construction of the Delhi Observatory. In the reign of Mohammed Shah, about the year 1710, Rajah Jeysing petitioned for leave to set up an observatory, having for its object the determination, with more accuracy than could at that time be attained, of the time of full and new moon, and other astronomical phenomena on which the religion and customs of the country were in part based. The Rajah seems to have been an accomplished courtier, for he addressed the Sultan as "the majesty of dignity and power, the sun of the firmament of felicity and dominion, the splendour of the forehead of imperial magnificence, the unrivalled pearl of the sea of sovereignty, the incomparably brightest star of the heaven of empire; whose standard is the sun, and retinue the moon; his lance is Mars, and his pen like Mercury; with attendants like Venus; whose threshold is the sky; whose signet is Jupiter; whose sentinel Saturn;" and a good deal more of the like kind. But he was something more than a courtier; for, having obtained the Shah's acquiescence to his request, he proceeded to build the observatory, of which a sketch is given in Fig. 1484.

This observatory, which seems to be in every respect a most remarkable structure, is situated about a mile from the city of Delhi. According to an account of it given in the 'Asiatic Researches,' it appears to be formed of several detached buildings. The first of these is a large equatorial dial, tolerably entire in its outline, but broken in several places. The gnomon or style of the dial measures one hundred and eighteen feet, its base is computed at one hundred and four feet, and its perpendicular height at nearly fifty-seven. It is built of stone; but the edges of the gnomon and of the graduated arches were of white marble, little of which now remains. The building was, in fact, a huge sundial, perhaps the largest ever constructed. Another building, forming a sundial of smaller size, is in better preservation; the gnomon, which stands in the middle, contains a staircase leading up to the top; and on either side of the gnomon are concentric semicircles, having a certain inclination to the horizon: they represent meridians removed by a certain angle from the meridian of the place. On each side of this part is another gnomon of equal size with the middle one; and a wall connects the highest points of the three. On this wall is described a graduated semicircle, for taking the altitudes of bodies lying east or west. Two other buildings are devoted to the determination of the altitude and the azimuth of the heavenly bodies, that is, their height above the horizon, and their direction with respect to the points of the compass. These buildings are circular, open at the top, and having a pillar in the centre of each. From this pillar, at the height of about three feet, branch out horizontally radii of stone to the circular wall; these radii are thirty in number; and the spaces between them are equal to the thickness of the radii, which increase in breadth as they recede from the pillar. In the wall, at the spaces between the radii, are recesses with holes, to enable a person to climb to the top, and containing each of them two windows. On the edges of the recesses are marked the degrees of the sun's altitude, as shown by the shadow of the pillar; the degrees being subdivided into minutes. The spaces in the wall are divided into six equal parts by lines drawn from the top to the bottom; by observing on which of these the shadow of the pillar falls, the sun's azimuth is determined.

There are other buildings comprised in this very remarkable observatory; and they may all be characterised not so much as places where instruments may be deposited for making astronomical observations, as enormous specimens of the instruments themselves. The transit instruments, and equatorial and altitude and azimuth circles of our own country are made of brass or other kinds of metal; but at Delhi such instruments, or at least others intended to work out the same results in a rougher way, are made of stone. Rajah Jeysing, when he obtained the consent of the Shah to the construction of an observatory, is said to have had instruments made of brass; but finding that these did not come up to the ideas which he had formed of accuracy, because of the smallness of the size, the want of graduation into minutes, the shaking and wearing of their axes, the displacement of the centre of the circles, and the shifting of the planes of the instruments, he determined to build large instruments of stone and lime, which, being fixed in position, should be free from many of these defects. The only building in this singular group which does not appear to be constructed of these materials is an instrument formed of mahogany, in the shape of a concave hemispherical surface, to represent the inferior hemisphere of the heavens. It is divided by six ribs of solid work and as many hollow spaces, the edges of which represent meridians at distances of 15° apart: the diameter of the instrument is more than twenty-seven feet.

Greenwich Observatory (Fig. 1506) is the most important one in this country. There was an old fortified tower on this spot, built in the time of Henry V., and repaired at intervals during the reigns of succeeding monarchs. In the time of Charles II. Flamsteed was employed to make out certain tables concerning the distance of the moon from the fixed stars at successive periods; and, as he stated that there was no building in England fitted for making astronomical observations relating to this subject, the king determined to erect one; and the site of the old tower on Greenwich Hill was selected. The building was finished in 1676, and has ever since been used as an observatory. Flamsteed was appointed the astronomer royal, and he pursued an indefatigable course of observation at Greenwich through the long period of forty-three years. The successors to Flamsteed were Halley, Bradley, Bliss, Maskelyne, Pond, and Airy, the last-named being the present occupier of this important position. Dr. Maskelyne was astronomer royal for a period of nearly half a century.

The observatory comprises both a residence for the astronomer royal and buildings for containing the various instruments. These instruments comprise transit circles, quadrants, clocks, zenith sectors, and most of those which were enumerated in a former page. There are two small hemispherical-domed buildings, the roofs of which slide or rotate, and furnish means for observing the movement of comets. Within the last few years, too, magnetic instruments have been added to the observatory, to aid in the great inquiries now prosecuting concerning the magnetism of the earth.

In an article on this subject in the 'Penny Cyclopædia' it is remarked that "An observatory is a very dull and uninteresting sight to any one who is not acquainted with the purposes to which it is applied; and we can scarcely conceive how Lalande could say, or others repeat after him, that a person would learn more of astronomy in one night in an observatory than in six months elsewhere. We should say there was no worse school; and that a person would learn astronomy far better from a celestial globe and a fine sky. It is probable, however, that Lalande supposed his learner to possess some elementary knowledge, and to be acquainted with the geometrical part of astronomy; in which case he would, no doubt, learn that in an observatory which is not to be learned or understood elsewhere. There is no perfect model of an observatory, as respects the building, to which we can refer. Cambridge is perhaps the best, but on a larger scale than is necessary. . . . . Greenwich has nothing to recommend it as a building; but the goodness of the instruments, and the number and methodical arrangement of the observations and computations, may be judged of from the printed Observations. The Royal Observatory (Greenwich) is only to be seen by the public at stated hours, and by leave from the Lords of the Admiralty. It is found necessary to adhere very strictly to this rule in the immediate vicinity of London, or a lounge over the observatory might soon become a usual preparation for a white-bait dinner."

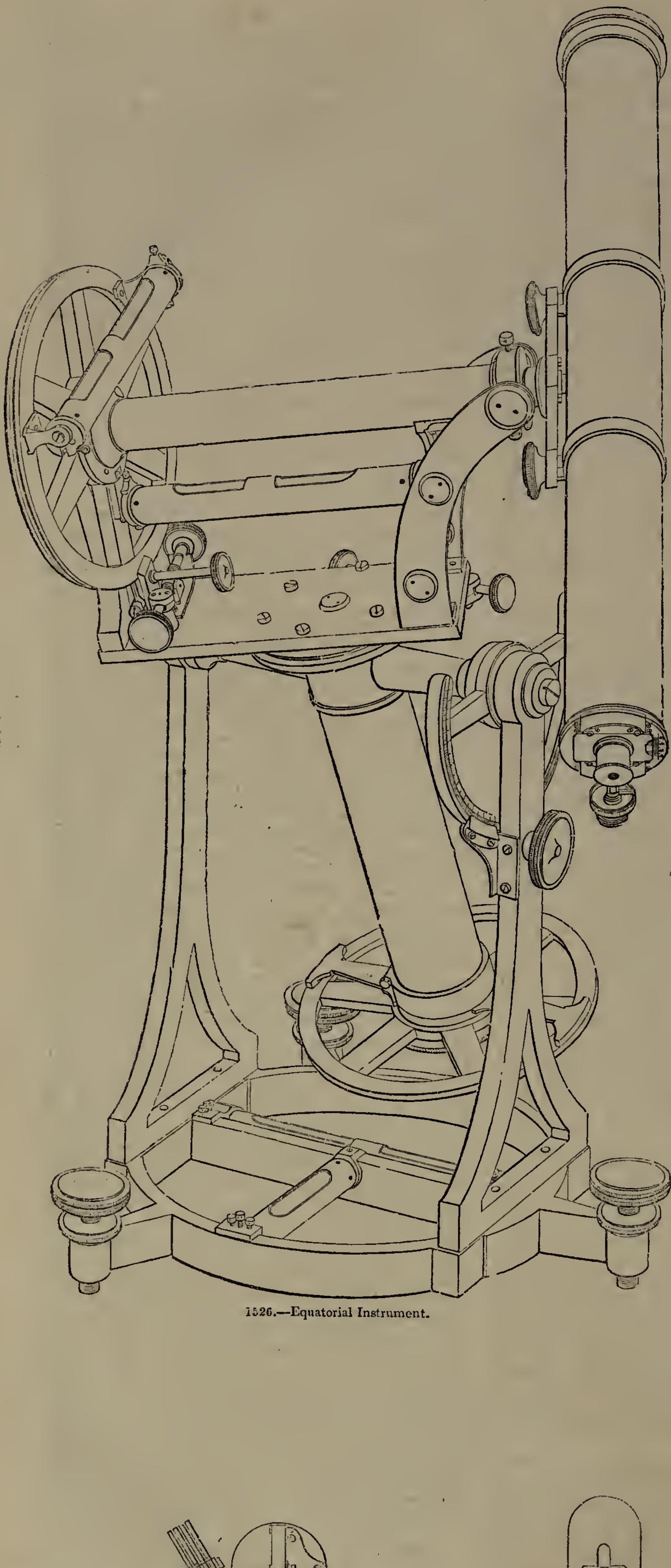
The humble classes have *their* observatories, too, as well as the learned. There are occasionally to be seen in the open squares of London itinerant astronomers (Fig. 1518), whose somewhat battered, but still available telescopes are pointed upward to the heavens, and whose business it is to dispense out, in pennyworths, a share of that sublime pleasure which results from a view of the beauties presented by the "starry firmament." Let not such science on an humble scale be despised: it is not without its benefits. As to the old Greenwich pensioners, who point their telescopes on the outside of the observatory, while the astronomer royal is possibly pointing his withinside, we can hardly include them in the same rank as the street philosopher; for the peep in their telescopes has much more frequently a terrestrial than a celestial object.

INSTRUMENTS FOR EXPERIMENTAL SCIENCE.

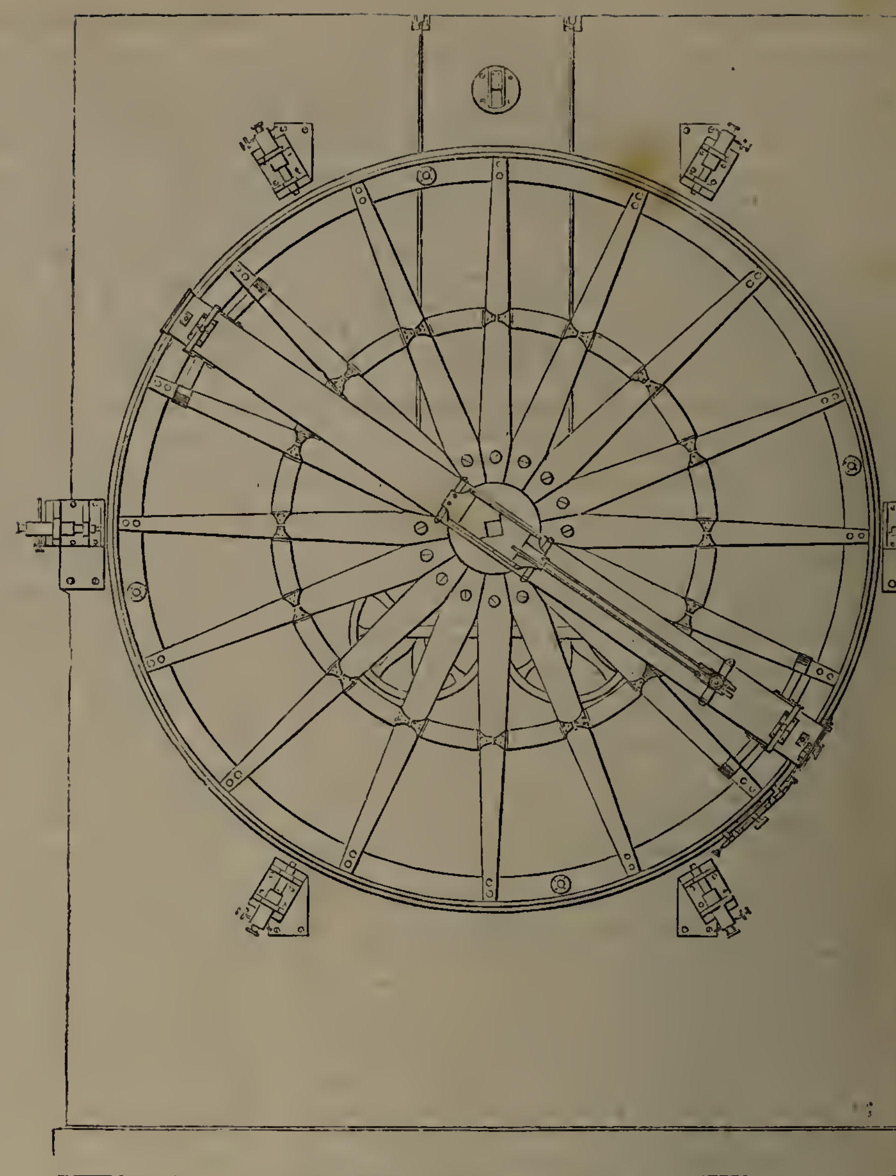
All the various branches of science call for the aid of the mechanical arts in the supply of instruments, whereby observations and experiments may be made. Whatever be the classification of sciences adopted—whether mechanics, hydrostatics, pneumatics, optics, heat, electricity, chemistry, &c., or any other order—a complete set of apparatus is necessary for each. Some of these have already engaged a little attention, and a few more call for notice.

Pneumatic and Mechanical Apparatus.

All the phenomena relating to the pressure, equilibrium, and motion of solid bodies come under the general name of "mechanics;" those of liquids, under that of "hydrostatics," or "hydrodynamics;" and that of air, under "pneumatics." The three classes have thus a bond of union, but the apparatus necessary for the prosecution of experiments concerning them differs very widely. In mechanics, for instance, the ques-

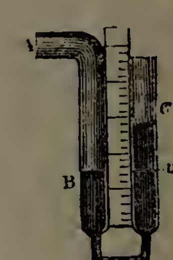


1526.—Equatorial Instrument.

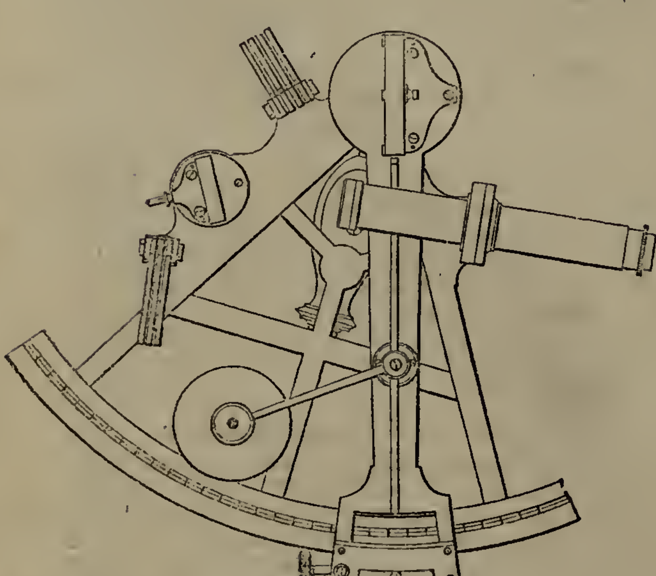


1527.—Mural Circle at Greenwich Observatory.

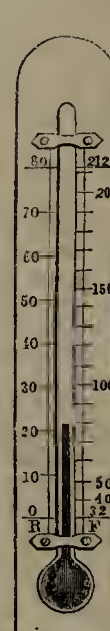
1528.—Eudiometer.



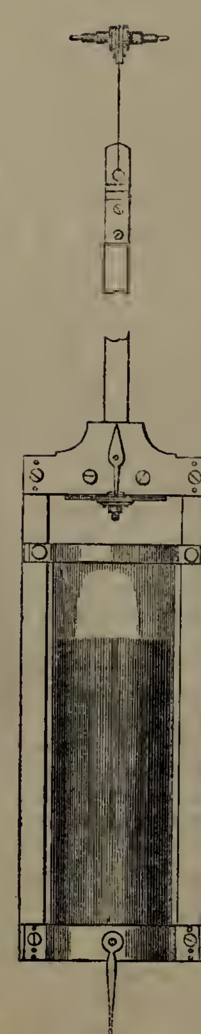
1529.—Anemometer.



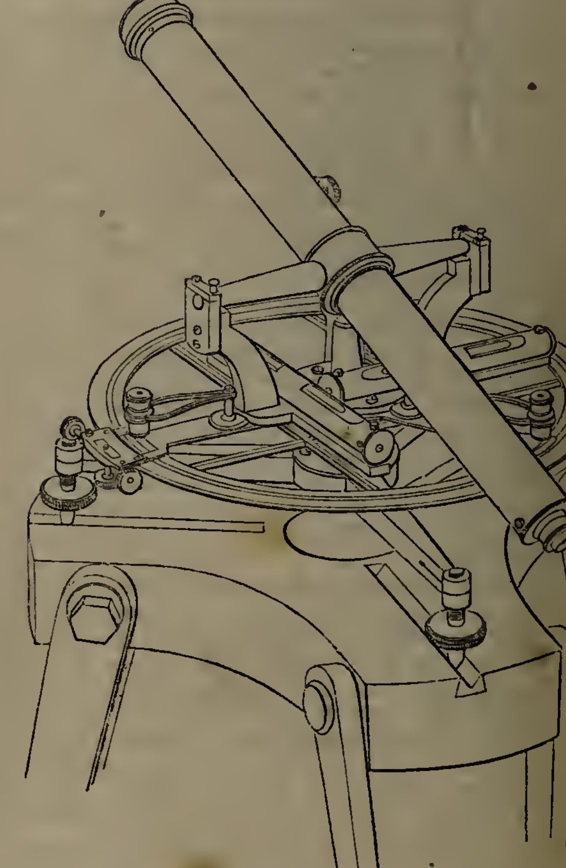
1530.—Sextant.



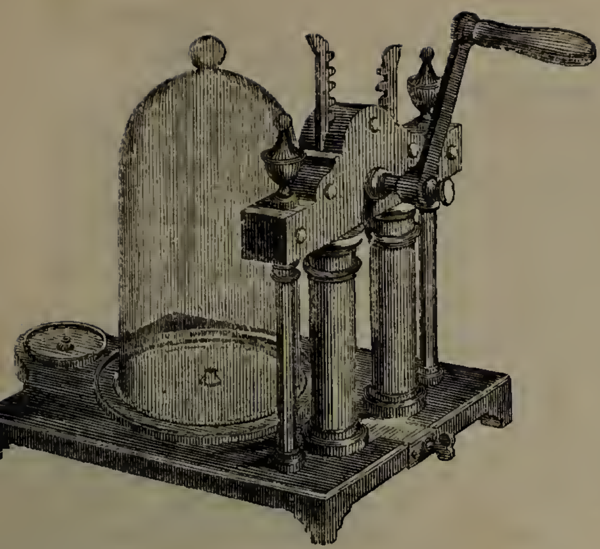
1531.—Fahrenheit's Thermometer.



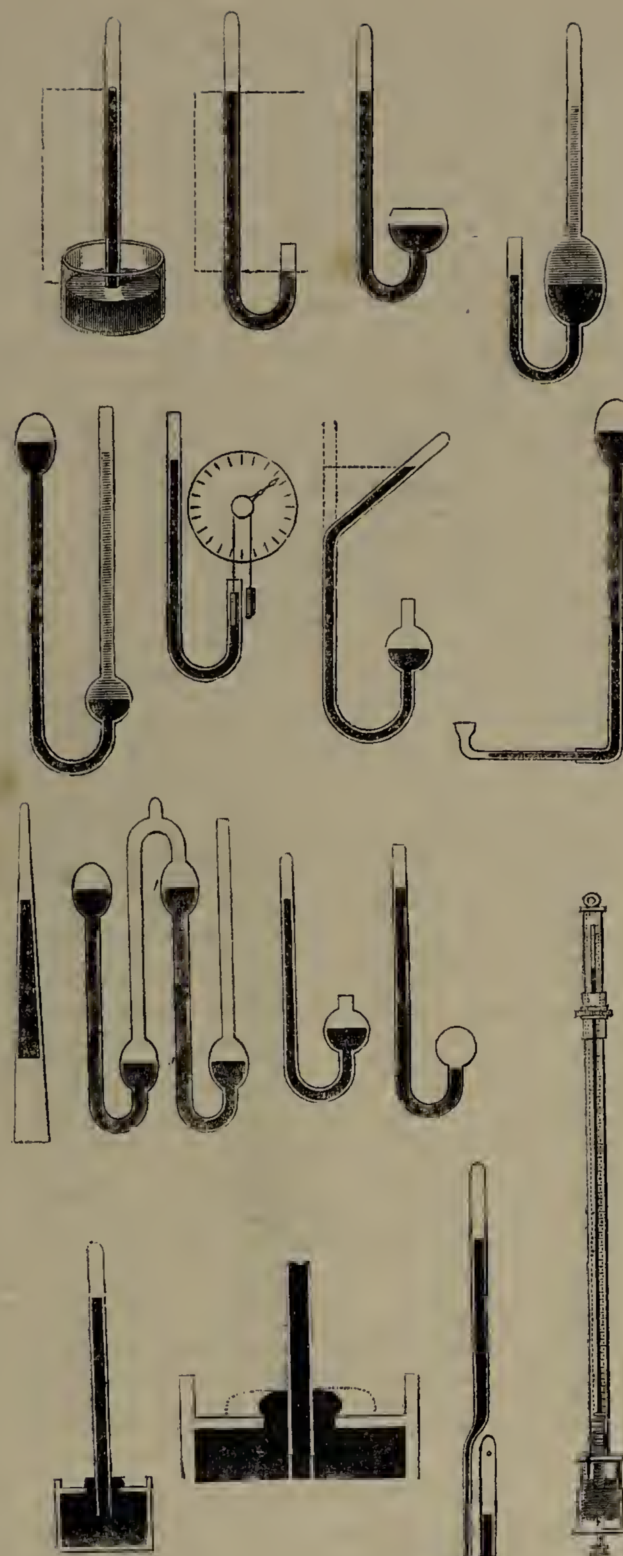
1532.—Mercurial Pendulum.



1533.—Theodolite.

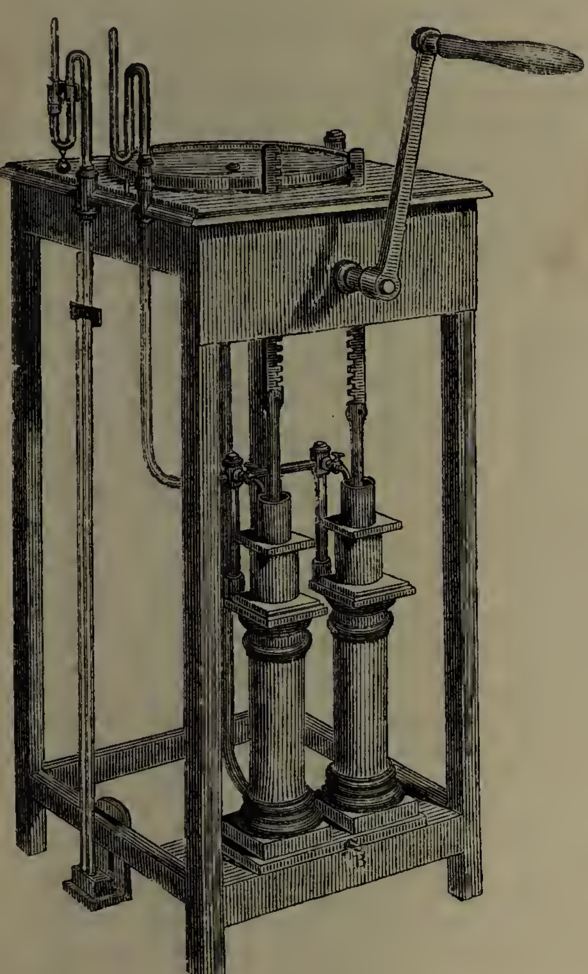


1534.—Air-pump.

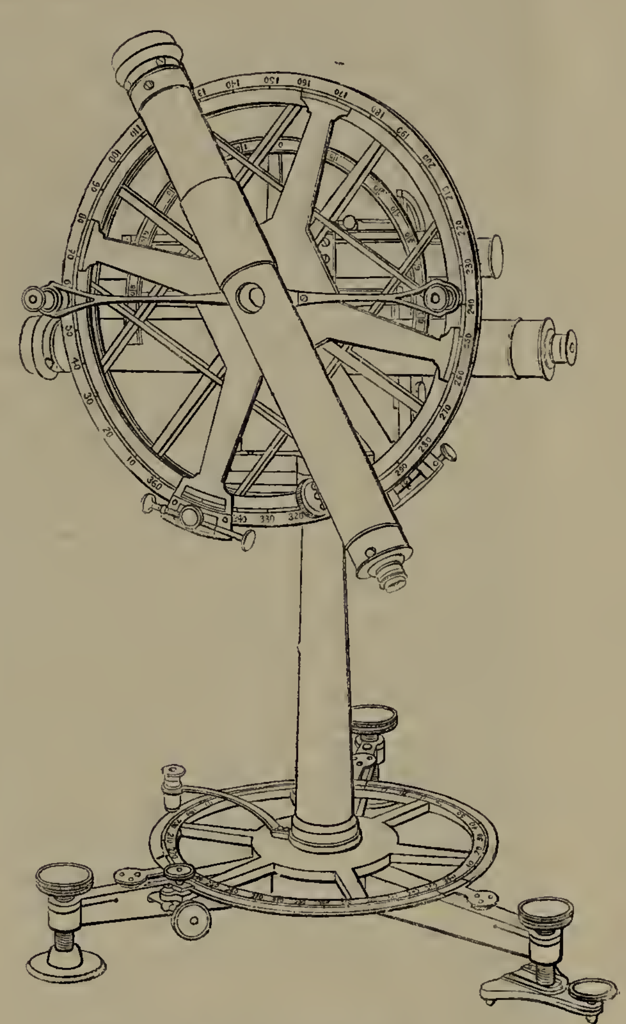


1536.—Various forms of Barometers.

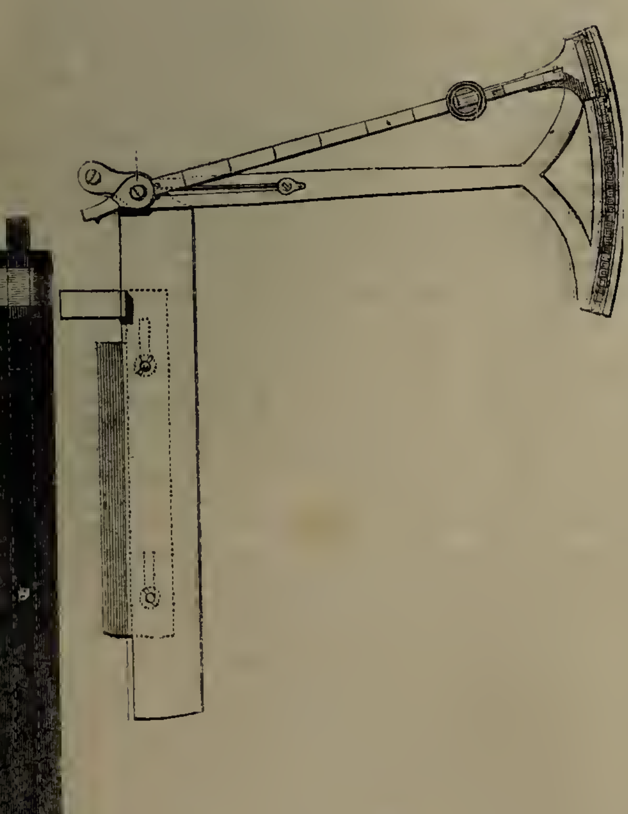
1537.—Blow-pipe.



1535.—Air-pump.

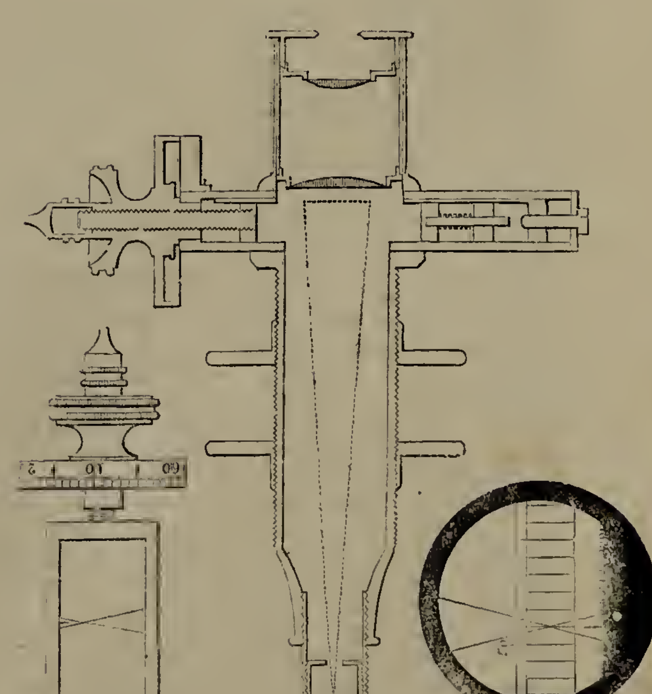


1538.—Borda's Repeating Circle.



1539.—Pyrometer.

1540.—Pneumatic Bellows.



1541.—Micrometer Microscope.

tions relate principally (so far as apparatus is concerned) to the properties of the lever, of the wheel and axle, of the inclined plane, of the pulley, of the screw, of friction and adhesion, of the communication or stoppage of motion, of wheels and pinions, and many others; the instruments in aid of which bear a good deal of resemblance in principle to those employed in millwork and engineering. Those which pertain to the equilibrium and motion of liquids comprise all the various kinds of siphons, pumps, water-wheels, tubes of larger or smaller diameter, valves, hydraulic presses, and numberless others. It is true that these may be regarded as practical applications of science to the purposes of everyday life, but they may also be ranked among the kinds of aid by which scientific truths have been proved. It is one of those examples of compensation alluded to in a former page, by which science tends to perfect the instruments, and the instruments tend to perfect science.

In pneumatics, or the science which takes cognizance of the pressure and movement of the air, the scientific instruments employed differ rather more from those employed in daily life than in the former instances. The air-pump, for instance, has been much more used as an instrument of scientific discovery than as one of practical application, though there are not wanting instances of the latter.

The machine just spoken of, the *air-pump*, carries us back to the time of Boyle, and to the important discovery, which he helped to demonstrate, concerning the *reality* of air, so to speak, or the power of weighing air, of dividing it, of rarefying it, of condensing it, and, in short, of treating it rather as a material substance than an ethereal spirit, which it had before been considered to be. Several distinguished philosophers aided in this work. Galileo made some very important determinations; and after him Otto Guericke, Consul of Magdeburg, succeeded in emptying glass vessels of their contained air, by drawing or sucking it out at the mouth of the vessel, plunged under water. Of this philosopher it is stated ('Pursuit of Knowledge,' vol. ii.) that, "In his original attempts to produce a vacuum, he used first to fill his vessel with water, which he then sucked out by a common pump, taking care, of course, that no air entered to replace the liquid. This method was probably suggested to Guericke by Torricelli's beautiful experiment with the barometrical tube, the vacuum produced in the upper part of which, by the descent of the mercury, has been called from him the Torricellian vacuum. It was by first filling it with water that Guericke expelled the air from the copper globe, the two closely-fitting hemispheres comprising which six horses were then unable to pull asunder, although held together by nothing more than the pressure of the external atmosphere. This curious proof of the force or weight of the air, which was exhibited before the Emperor Ferdinand III. in 1654, is commonly referred to by the name of the experiment of the Magdeburg hemispheres."

These hemispheres became the progenitors of the air-pump. Guericke wished to adopt some mode of producing a vacuum without previously filling the vessel with water. By a very ingenious arrangement of tubes and valves, he succeeded in producing a machine which, when worked like a pump, would draw out the air from a vessel, just as if it were water; by placing valves so that the air, when once driven out by its own elasticity, could not return. But his air-pump was very defective, and many of these defects led to the experiments of Boyle for their removal. "Among others with which it was chargeable, it required the continual labour of two men for several hours at the pump to exhaust the air from a vessel of only moderate size; the precautions which Guericke used to prevent the intrusion of air from without, between the piston and the sides of the barrel during the working of the machine, were both imperfect for that purpose, and greatly added to the difficulties and incommodiousness of the operation; and, above all, from the vessel employed being a round globe, without any other mouth or opening than the narrow one in which the pump was inserted, things could not be conveyed into it, nor, consequently, any experiments made in that vacuum which had been obtained. Boyle, who says that he had himself thought of something like an air-pump before he heard of Guericke's invention, applied himself, in the first place, to the remedying of these defects in the original instruments, and succeeded in rendering it considerably more convenient and useful. At the time when he began to give his attention to this subject he had Robert Hooke, who afterwards attained a distinguished name in science, residing with him as an assistant in his experiments; and it was Hooke, he says, who suggested to him the first experiments in Guericke's machine. These, which could not easily be made intelligible by any mere description, and which, besides, have long since given way to still more commodious modifications of the apparatus, so that they possess now but little interest, enabled Boyle and his friends to carry their experiments with the new instrument much farther than had been done by the Consul of Magdeburg. But, indeed, Boyle himself did not long continue to use the air-pump which he describes in his first publication. In the second part of his Physico-Mechanical Experiments he describes one of a new construction; and in the third part of the same work one still further improved."

Two forms of air-pump, as brought into workable form by Boyle and his successors, are sketched in Figs. 1534, 1535. The object of such instruments is to draw out the air from a glass receiver or other vessel, by means of a pump and a system of valves; and then to institute various experiments on the nature of the vacuum thus produced: such as the respiration of animals, the combustion of flame, the elasticity of air, and so on. This elasticity, shown in an opposite sense, that is, when the air is increased in bulk or quantity instead of diminished, is also shown by a familiar experiment, conducted in the way shown in Fig. 1540, which is copied from an old print. This piece of apparatus consists of a kind of bellows, having wooden top and bottom, and flexible leather sides. A tube is fixed in a hole pierced through the upper board, of such a height that the upper end may reach nearly to the level of the mouth. The person who makes the experiment stands upon the upper board of the bellows; and on blowing through the tube, he finds that he is able to lift himself several inches by the mere force of his breath: the air which is thus driven into the bellows, having no means of escape, and meeting with an elastic mass of air already in the bellows, makes room for itself by lifting up the upper board of the bellows, and thus increasing the capacity of the chamber in which it is confined. The two reverse operations alluded to here, the one of rarefaction and the other of condensation, are also brought about with much facility by the two vessels sketched in Fig. 1549, where, in the right-hand vessel, the valves are so regulated as to draw out all the air from the globular vessel, when the piston is worked by the handle, whereas in the other vessel they are so placed as to increase the density of the air in a vessel already containing its natural quantity. It is by an air-condenser, such as that here alluded to, that the "Air-gun" (Fig. 1547) is charged. There is in this air-gun such an arrangement of parts, that when the bullets and powder are in their proper place, the admission of highly condensed air behind them will discharge them, with a force similar in kind to that of gunpowder, though smaller in amount; and the apparatus is adjusted for the reception of this condensed air from the air-condenser.

It forms no part of the present object to trace the numberless remarkable and beautiful results which follow from the principles revealed by the air-pump and similar instruments: it will suffice to have glanced briefly at the kind of aid which they, as mechanical pieces of apparatus, have rendered to the science of Pneumatics.

Electrical and Chemical Apparatus.

The Electrical Sciences are among those which have been largely indebted to mechanical apparatus for the determination of truths which could not have been developed without such aid. The very name itself indicates the experimental origin of the science; for the word "electricity" is derived from the Greek name for "amber:" the phenomena first observed having been those which resulted from the rubbing of a piece of amber. The electrical machine (Fig. 1544) is, like most specimens of the kind, the result of a long series of trials and researches, during which many different forms of apparatus were employed.

The services which Franklin—the printer, the philosopher, the essayist, the statesman—rendered in these matters, was of so peculiar and interesting a kind, that we must say a little respecting them; especially as they illustrate the simple mechanical aids which become valuable in the hands of a clever man. Franklin's object was to discover whether the lightning from clouds was the same agent as electricity from a machine; and the plan which he adopted is thus sketched in a 'Life of Franklin,' published by Messrs. Chambers:—

"The plan which he had originally proposed was to erect on some high tower or elevated place a sentry-box, from which should rise a pointed iron rod, insulated by being fixed in a cake of resin. Electrified clouds passing over this would, he conceived, impart to it a portion of their electricity, which would be rendered evident to the senses by sparks being emitted, when a key, the knuckle, or other conductor, was presented to it. Philadelphia at this time afforded no opportunity of trying an experiment of this kind. While Franklin was waiting for the erection of a spire, it occurred to him that he might have more ready access to the region of clouds by means of a common kite. He prepared one by fastening two cross-sticks to a silk handkerchief, which could not suffer so much from the rain as paper. To the upright stick was affixed an iron point. The string was, as usual, of hemp, except the lower end, which was silk. Where the hempen string terminated a key was fastened. With this apparatus, on the appearance of a thunder-gust approaching, he went out to the common, accompanied by his son, to whom alone he communicated his intentions, well knowing the ridicule which, too generally for the interests of science, awaits unsuccessful experiments in philosophy. He placed himself under a shade to avoid the rain—his kite was raised—a thunder-cloud passed over it—no sign of electricity appeared. He almost despaired of success, when suddenly he observed the loose fibres of his string to move towards an erect position. He now presented his knuckle to the key, and received a strong spark. How exquisite must his sensations have been at this moment! On this experiment depended the fate of his theory. If he succeeded, his name would rank high among those who had improved science; if he failed, he must inevitably be subjected to the derision of mankind, or, what is worse, their pity, as a well-meaning man, but a weak silly projector. The anxiety with which he looked for the result of his experiment may be easily conceived. Doubts and despair had begun to prevail, when the fact was ascertained in so clear a manner that even the most incredulous could no longer withhold their assent. Repeated sparks were drawn from the key, a phial was charged, a shock given, and all the experiments made which were then usually performed with electricity."

The instruments which, since the days of Franklin, have been invented for conducting electrical experiments, are both numerous and varied; requiring for their manufacture very carefully prepared pieces of glass, brass, and resinous compositions. The "electrical machine" is generally either a cylinder of glass, closed at both ends, or a circular flat disk of plate-glass; but in either case there is a provision for causing it to rotate on its axis, and also to be rubbed while rotating with some resinous substance: since it is by means of this friction that the electricity is developed. Besides the "electrical machine" for developing electricity, there are "conductors," "dischargers," "electroscopes," "electrometers," the "Leyden jar," the "electrophorus"—and a host of others, employed in those researches which belong to Electricity, usually so called. Then again there are others of an entirely distinct kind, belonging to that part of the great science to which the distinctive name of Galvanism is applied. Most of the former kind are kept and used perfectly dry; most of the latter require the use of some kind of liquid, comprising "batteries," "cells," "troughs," and other apparatus for containing liquids and metals capable of exerting a galvanic agency one on another. Besides all these, there are the complicated and delicate pieces of apparatus which illustrate the wonderful connexion between Magnetism and Electricity—a connexion which has led to the "electrical telegraphs" and "clocks" of modern times, and which, in the hands of Professor Faraday, seems at the present day likely to lead to the discovery of a further connexion between all these agencies and light. The instrument-makers, by whom all these pieces of apparatus are brought into working form, render the same kind of services to science as those who make astronomical instruments; they learn, from the results of scientific inquiry, the relations existing between certain liquids, metals, and other material substances; and they fabricate, in accordance with these relations, instruments which enable the man of study still farther to extend the range of science.

The Science of Chemistry is so nearly allied to the Electrical Sciences, that every day lessens the power of showing where one begins and the other ends; indeed they seem to be co-existent at all times and under all circumstances. There were, however, various discoveries of great importance made in chemistry before any particular connexion was known between it and electricity. Such men as Priestley, Black, Lavoisier, Gay-Lussac, &c., made discoveries quite of a chemical character, which paved the way for the subsequent establishment of a connexion between this science and electricity; and the instruments which they constructed, or caused to be constructed, for these purposes, were among the important means of amplifying the range of the subject.

One of the chemical philosophers here named, Dr. Black, was the first to establish the important doctrine of "latent heat;" by which it is shown that there is in all liquids a quantity of heat which belongs expressly to the liquid form, and cannot be detected by the thermometer; or, in other words, that the heat existing in any liquid at any time may be considered as two different portions, one of which is discernible by the thermometer, while the other is not. He also showed that when the same liquid, whatever it might be, is converted into vapour, it absorbs another very large quantity of heat, which becomes "latent" or "hidden," so far as the thermometer is concerned. Steam may show a thermometric temperature of 212°, and water also a temperature of 212°; but there is a great deal more heat in a given weight of the former than of the latter: all the extra portion being "latent" heat. This discovery, which does not at the first glance seem very important, was one of the chief circumstances which led to the improvement of the steam-engine by Watt; and here, therefore, we have another to add to the list of examples of the mutual aid between Science and Art.

Dr. Priestley was another of the great names in chemical discovery. He either discovered, or placed

on a more definite footing, oxygen gas, nitrous gas, carbonic oxide, ammoniacal gas, and many other gases which have since become of vast importance in the laboratory and in the works of chemical manufacturers. He showed that the red colour of arterial blood resulted from its combination with the oxygen of the atmosphere; that the change produced in atmospheric air during the procession of combustion and putrefaction arose from a similar abstraction of oxygen. He invented a simple piece of apparatus called the "pneumatic trough," which has been very valuable in researches concerning the gases. In various other ways he aided the practical details of chemistry. Dr. Thomson says of him:—"No one ever entered upon the study of chemistry with more disadvantages than Dr. Priestley, and yet few have occupied a more dignified station in it, or contributed a greater number of new and important facts. The career which he selected was new, and he entered upon it free from those prejudices which warped the judgment and limited the views of those who had been regularly bred to the science. He possessed a sagacity capable of overcoming every obstacle, and a turn for observation which enabled him to profit by every phenomenon which presented itself to his view. His habits of regularity were such that everything was registered as soon as observed."

A few of the smaller kinds of apparatus employed in chemical manipulations were sketched in p. 305. Two or three others may be very briefly alluded to. The "blow-pipe," sketched in Fig. 1537, from an old print, is an example of the mode of directing a current of air into a flame, in order that the heat of the flame may be raised so high as to melt or ignite chemical substances which would be otherwise refractory in the fire. Figs. 1542, 1550, are "Alembics," vessels used in distillation. Figs. 1543, 1551, are delicately constructed glass vessels, with arrangements for heating the contents of retorts, and for collecting the gaseous products in other vessels, for the purpose of separating the component ingredients of a compound chemical substance. Great variety of form is observable in chemical apparatus of this kind. The instruments relating to chemistry are perhaps more numerous than those necessary for any other branch of science: lamps, stills, alembics, sand-baths, water-baths, pneumatic troughs, alkilimeters, blow-pipes, jars and vessels for liquids and gases, crucibles and melting-pots, tubes and pipes of various kinds, flasks and funnels, crystallizing and evaporating vessels, retorts and receivers, scales and weights, pestles and mortars—all form a collection which shows how largely experimental chemists are indebted to the ingenuity of instrument-makers.

Meteorological Instruments.

Some of the most delicate instruments made are those intended for meteorological observation. Meteorology, although for convenience designated a separate science, is not so in reality, for it is made up of the sciences relating to pneumatics, to heat, to chemistry, to light, to electricity, to magnetism; so that all the instruments belonging to meteorological research might be classed either under one heading or under many distinct headings.

The *thermometer* is one of the most useful of these. In its usual form, as planned by and named after Fahrenheit (Fig. 1531), it is a glass tube terminated at the bottom by a bulb containing mercury, and the temperature of the room or space where the instrument is deposited, is determined by the height to which the mercury rises in the tube. There is a graduated scale placed behind or at the side of the tube, as a means of affording numbers by which the height of the mercury may be recorded. In the graduation of this scale, Fahrenheit adopted one system, Réaumur another, Celsius another, Murray another, Leslie another, Sturmius another (Fig. 1548); but the principle of the instrument is the same in all, viz. the expansion of a liquid when the temperature or heat is raised. In some thermometers spirit is the liquid employed instead of mercury. Solids, too, expand by heat; and this expansion has given rise to various mechanical instruments; such as the *pyrometer*, of which one form, due to the late Professor Daniell, is shown in Fig. 1539; having for its object the determination of the temperature of a highly heated solid body, by measuring the degree to which it has become expanded in length under the influence of the heat. Another kind of instrument resulting from the same property is the *thermostat* of Dr. Ure (Figs. 1545, 1552); the object of which is to regulate the opening and shutting of valves, dampers, doors, and other moveable parts of machinery, by the expansion of certain pieces of metal when highly heated, and their contraction when cold; the whole being so regulated as to give the machine a self-acting power in respect to the increase or diminution of heat.

The termination "meter" is very frequently employed in the designation of instruments intended for meteorological and similar purposes. It means "measure," or "measurer," and is so applied because the object in view is not only to determine the existence of the particular natural agent, but in some sense also the *quantity* of it. The two words "microscope" and "micrometer," used in optical science, conveniently illustrate this matter: the former means simply to *view* or to *perceive* small objects; but the latter means something more—it enables the observer to *measure* the size of this small object, by comparing it with some previously prepared scale. Meteorological observations are worth very little, unless some attempt be made to measure quantities or degrees, or intensities; and hence the affix "meter" is more frequently used than "scope" to the names of the instruments employed.

The *eudiometer* (Fig. 1528) is one of the "meters" here alluded to. It was invented by Dr. Priestley, as a means of determining the purity of atmospheric air derived from different places. It acts on this principle: that by exposing the air to the action of some substance which has an affinity for oxygen, the remaining components of the air become separated and fit for examination. This instrument has afforded the means of showing that the atmospheric air is liable to no essential change of composition, except such as arises from local and temporary causes. The *anemometer* (Fig. 1529) is one form of "wind-gauge," intended—not merely to show the *direction* of the wind, which a common weather-cock might do—but the *intensity* of it also. The kind here shown acts on the principle of allowing wind to enter the open end of a bent tube, and then to press on the surface of water within the tube: the height to which the water is driven in the other part of the tube is made to measure the strength of the wind. Various other modes are adopted for bringing about the same result.

The *barometer*, according to its name, signifies a measurer of *weight*; but this is an indistinct designation, for the instrument relates only to the weight or pressure of the air and gases, and not to that of solid or liquid bodies. It consists generally of mercury contained in a vertical tube, so circumstanced as to be acted on by the pressure of the atmosphere at one end, but shielded from it at the other; and the height to which the mercury rises is made to indicate the degree of atmospheric pressure at that time and place. The modes of arranging the several parts of the instrument, or at least of the tube containing the mercury, are very numerous; as witness those sketched in Fig. 1536. The *hydrometer* (Fig. 1546) is not so much a meteorological instrument as one employed in commerce; since it is generally prepared for the purpose of determining the quantity of the lightest of two liquids in a common mixture. For instance, alcoholic liquors always contain pure spirit mixed with water, the former having the smaller specific gravity of the two; and an hydrometer furnishes the means of determining the relative quantities of spirit and water contained in the mixture, as was more fully alluded to in a former Chapter (p. 23).

Other instruments, designated the *hygrometer*, for determining the degree of moisture in the air; the *pluviometer*, or rain-gauge, for ascertaining the quantity of rain which has fallen within a given time; the *actinometer*, for measuring the intensity of heat in a sun-beam; the *cyanometer*, for measuring the degree of blueness in the sky, &c., help to make up the number of those which are valuable in meteorological research.

All these instruments depend for a good deal of their importance on the accurate manufacture of the glass tubing, which forms one of the main features in them. If this tubing is not equal in bore throughout, the indications of the instrument become liable to error, and may then throw the observer himself into a wholly mistaken train of reasoning. The very remarkable way in which these tubes are made, was described in the details relating to the manufacture of flint-glass, in p. 167.

INSTRUMENTS FOR MEASURING TIME.

The last class of instruments which will engage our attention comprises some which might perhaps have been noticed in an earlier page; since they may be deemed astronomical, or mechanical, or mathematical, according to the aspect under which they are viewed; but it is well to group them all together.

Sun-dials, Water-clocks, and Hour-glasses.

One of the modes adopted by rude nations, both in past times and present, has been to measure the length and direction of the shadow which the sun's light causes when an opaque object is interposed. The sun, as is well known, reaches his greatest altitude on any one day at twelve at noon; and the shadow of a stick, or other object, projected on the ground, is shorter then than at any other hour in the day. Consequently, if a stick of any given length were employed, and the length of the shadow derived from it on each of the successive hours noted, it might furnish a rough means of determining the hour of the day at any subsequent period; provided some mode were adopted of making allowance for the varying elevation of the sun at different seasons of the year—a matter, however, of considerable difficulty in such rough observation. So far as it went, this mode of determining the lapse of time by the length of shadow was (and probably is) followed by many nations of the East and of Africa.

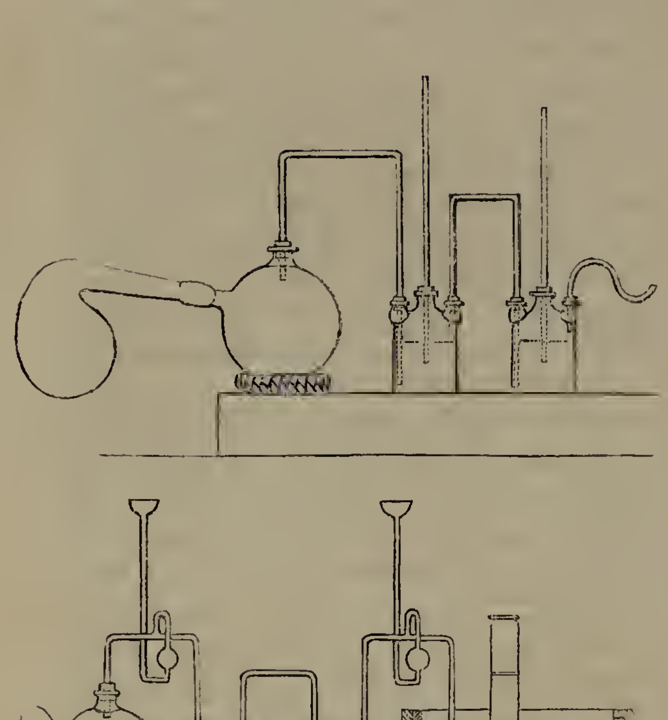
The *sun-dial*, however, which measures time by the *direction* of a shadow instead of by its *length*, is a much more serviceable piece of apparatus. In this there is always a "style," or "gnomon," or straight rod, so fixed as to maintain a position pretty nearly parallel with the axis of the earth. Besides this gnomon, there is always a surface more or less flat, on which graduated marks are engraved: these afford the means of obtaining the desired indication; for the gnomon is so fixed as to throw its shadow successively upon all these lines; and the construction of the instrument is so managed that these conjunctions of the shadow with the lines shall take place at regular hours every day—subject to that correction which is known by the name of the "Equation of Time."

Provided the gnomon be parallel with the earth's axis, it matters little what the shape of the dial or graduated surface may be: the manner of graduating the surface must depend upon this shape; but this being attended to, there is room for wide diversity in the form of the instrument. Sometimes there is no separate piece of wood, or metal, or stone, to form a gnomon; but one of the edges of the instrument is so contrived as to throw the requisite shadow. We have examples of this in p. 384, where there are eight different kinds of sun-dials—all employed to determine time by the shadow of an opaque object exposed to sunshine, but showing the degrees and hours in a very different manner. In Fig. 1561 it is a quarter of a hollow hemisphere, with a small gnomon at the top; in Fig. 1562 it is a four-sided mass of stonework, with the edges so planned as to act as a gnomon; in Fig. 1563 it is something like the one first described, but having a small opening or notch instead of a style; in Figs. 1564 and 1567 they have hollowed surfaces of curious forms, with apparently an edge for a gnomon; in Fig. 1568 it is shaped like a joint of meat, with a hook at one edge as a gnomon; Figs. 1569, 1571, represent two kinds of "ring-dials," which were used in our own country in by-gone ages, and which seem to have acted as time-measurers in some such a way as the common sun-dial.

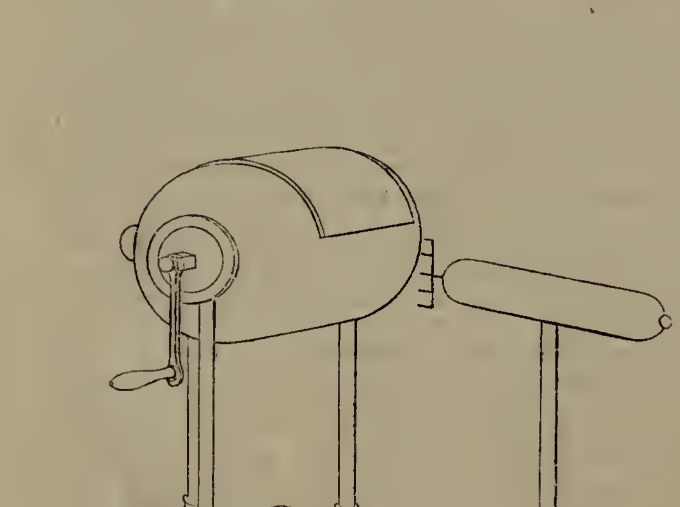
Besides this method of adopting the sun's shadow as a time-measurer, many others have been partially adopted, depending on principles having very little mutual relation. In the time of Alfred the Great time was often measured in England by the burning of candles—a custom which has been handed down in an altered form in the sales by auction, "by the candle," in which each bidding must be made by the time a certain length of candle has been burnt out. In Japan they formerly used to burn matches or torches made of plaited rope, which burned from knot to knot in one hour.

Among the ancient Greeks a time-measurer was in use called the "Clepsydra," or water-clock. They were, in general, so arranged that a given quantity of water would flow out of a vessel in exactly half a day, or in exactly a whole day; and the aperture by which the water escaped was so placed that the quantity which flowed in sixty minutes was always equal, whether the vessel were nearly full or nearly empty. This being the principle, the modes of carrying it out were very varied according to the ingenuity of the workmen. Among the clepsydræ of which descriptions have been handed down to modern times one made by Ctesibius had a little model of the human figure, whose head was dejected and drooping; out of the eyes dropped tears of water, which fell into a vessel beneath, and on the water in this vessel gradually rose a second figure, which floated on it and pointed with a wand to the days and hours marked on a vertical pillar in front of him: all this was brought about by siphon tubes and small water-wheels within the machine, and by filling a small cistern with water every twenty-four hours. Other clepsydræ had such an elaborate combination of wheelwork added to the mere hydraulic part of the apparatus, that the machine would not only indicate the division of a day into hours, but also the age of the moon and the position of the sun in the ecliptic. In Rome the use of clepsydræ became very common, and was made the subject of singular customs. Some of them were so large that one was considered sufficient for the smaller provincial towns of the empire. It was generally situated in an open place or square, where it was attended or guarded by a slave. The wealthy classes used to employ servants, generally young boys or girls, to go to this spot when necessary, in order to bring word as to the hour of the day. At regular intervals the attendant at the clepsydra, when the water reached certain graduated marks, blew a horn as a signal for changing the guard, and this horn being heard pretty well throughout the town, served to notify the hour to the inhabitants generally. In the Senate and the Roman courts the speeches of the senators and advocates were limited in length according to certain rules, and a clepsydra was kept to measure the time correctly. So jealous were the

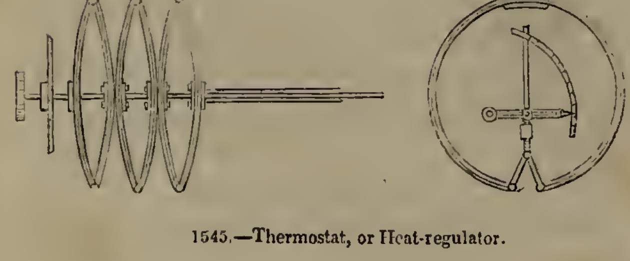
1542.—Alembic.



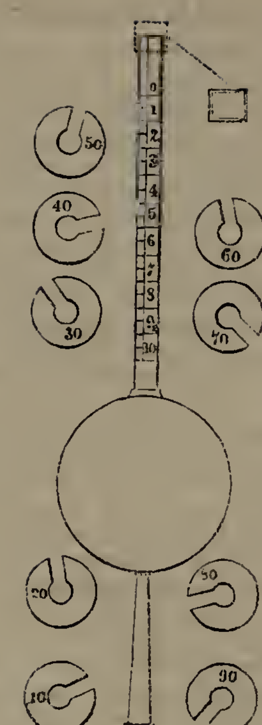
1543.—Woulfe's Chemical Apparatus.



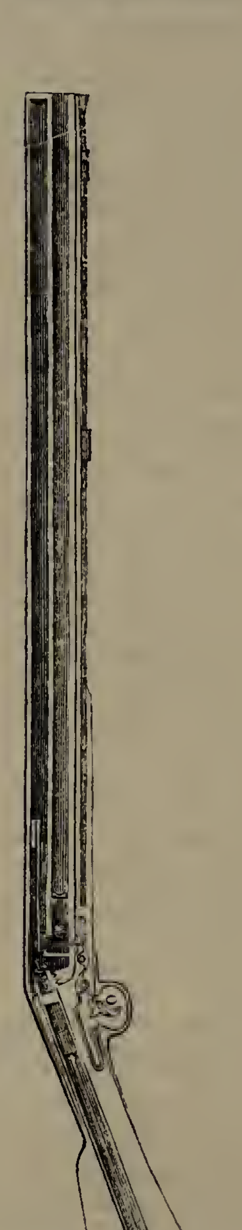
1544.—Electrical Machine



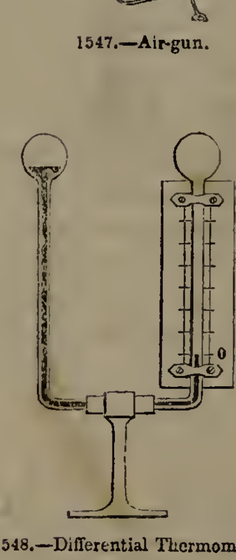
1545.—Thermostat, or Heat-regulator.



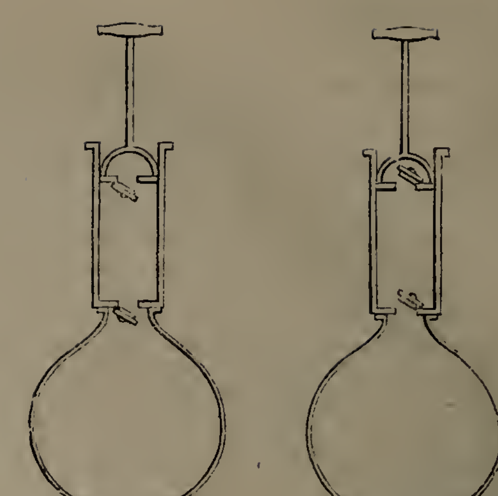
1546.—Sykes's Hydrometer.



1547.—Air-gun.

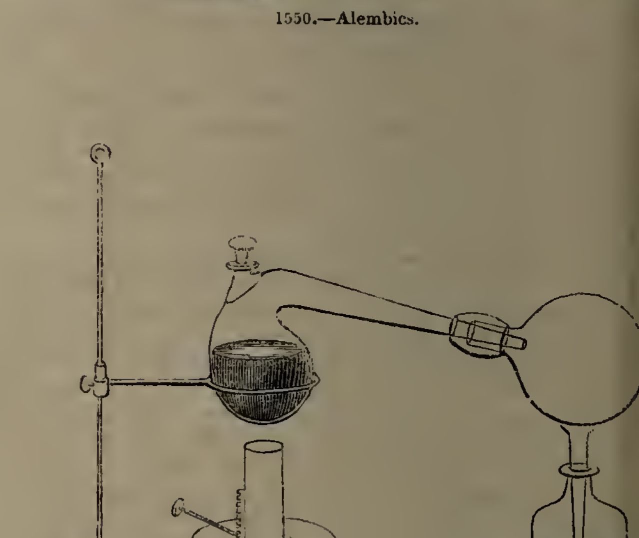


1548.—Differential Thermometer.

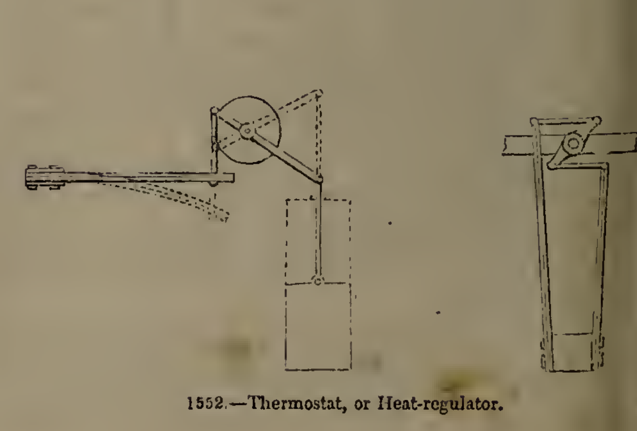


1549.—Air Condenser and Exhauster.

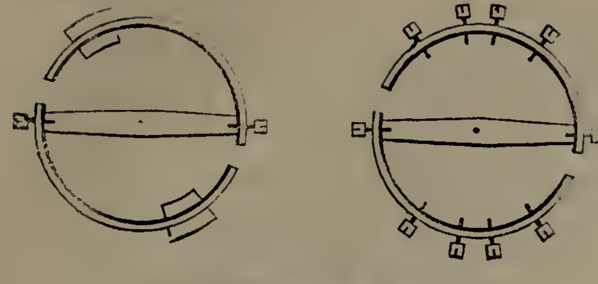
1550.—Alembics.



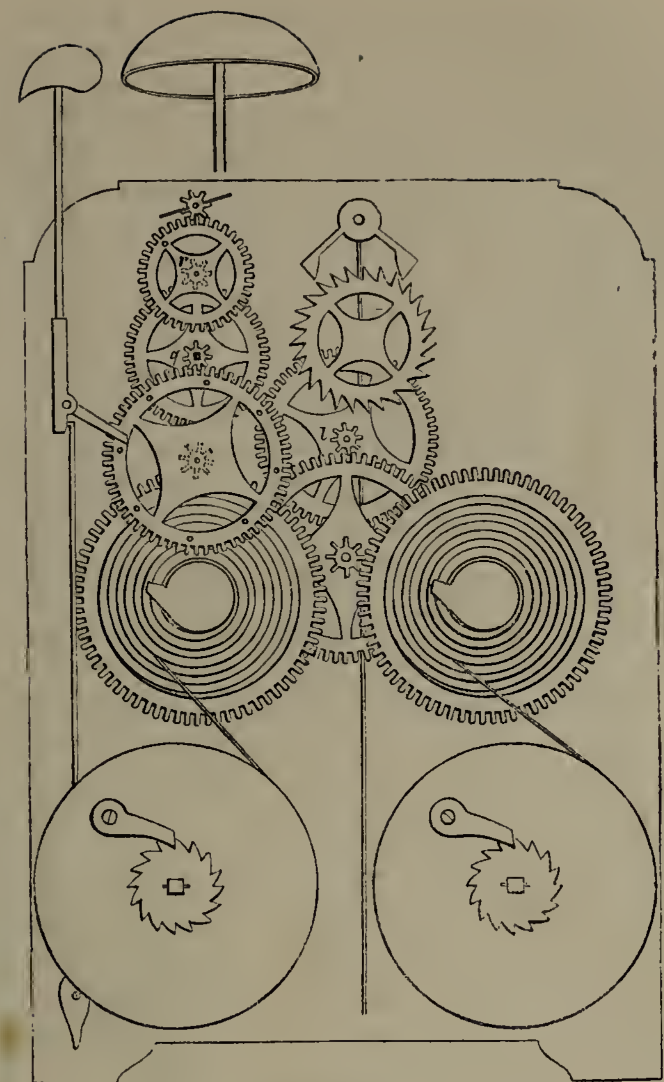
1551.—Retort Apparatus.



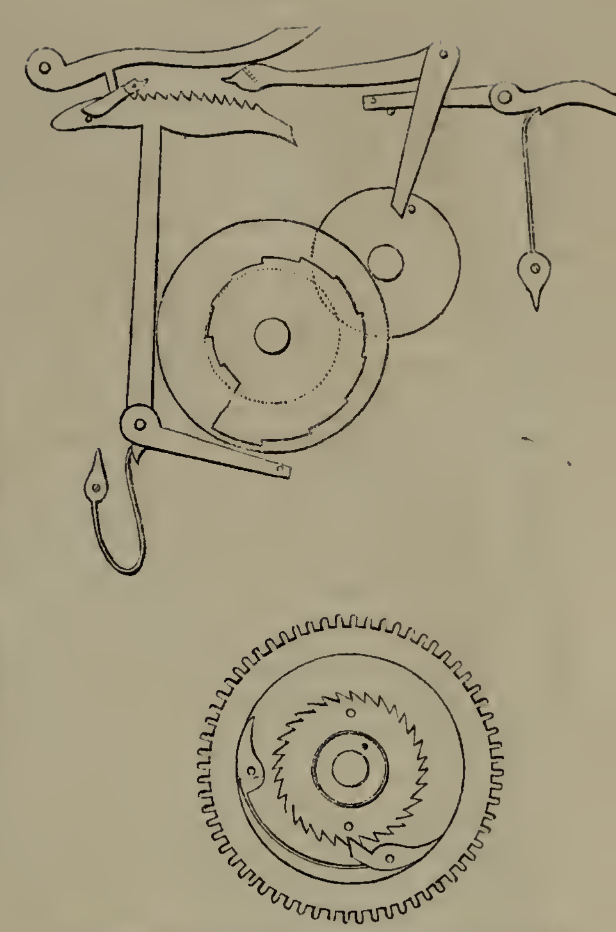
1552.—Thermostat, or Heat-regulator.



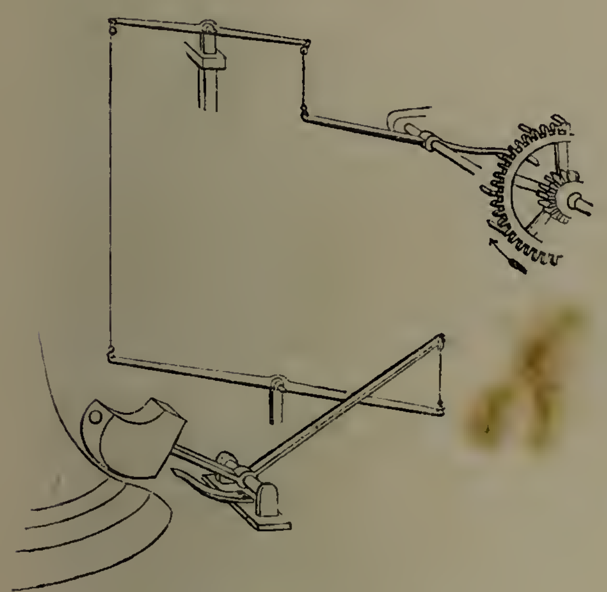
1553.—Compensation Pendulums.



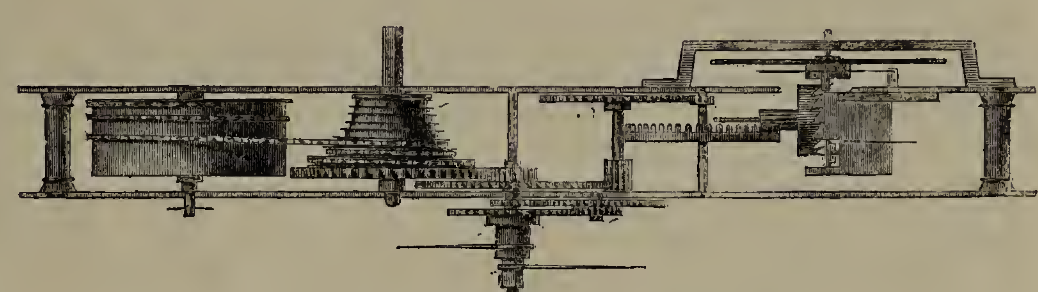
1555.—Eight-Days Clock.



1556.—Striking Mechanism and Fusee-Wheel of an Eight-Days Clock.

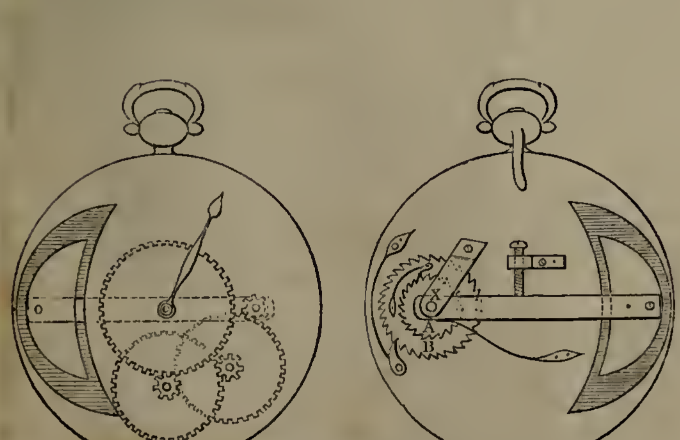


1554.—Striking-apparatus of a Turret-Clock.

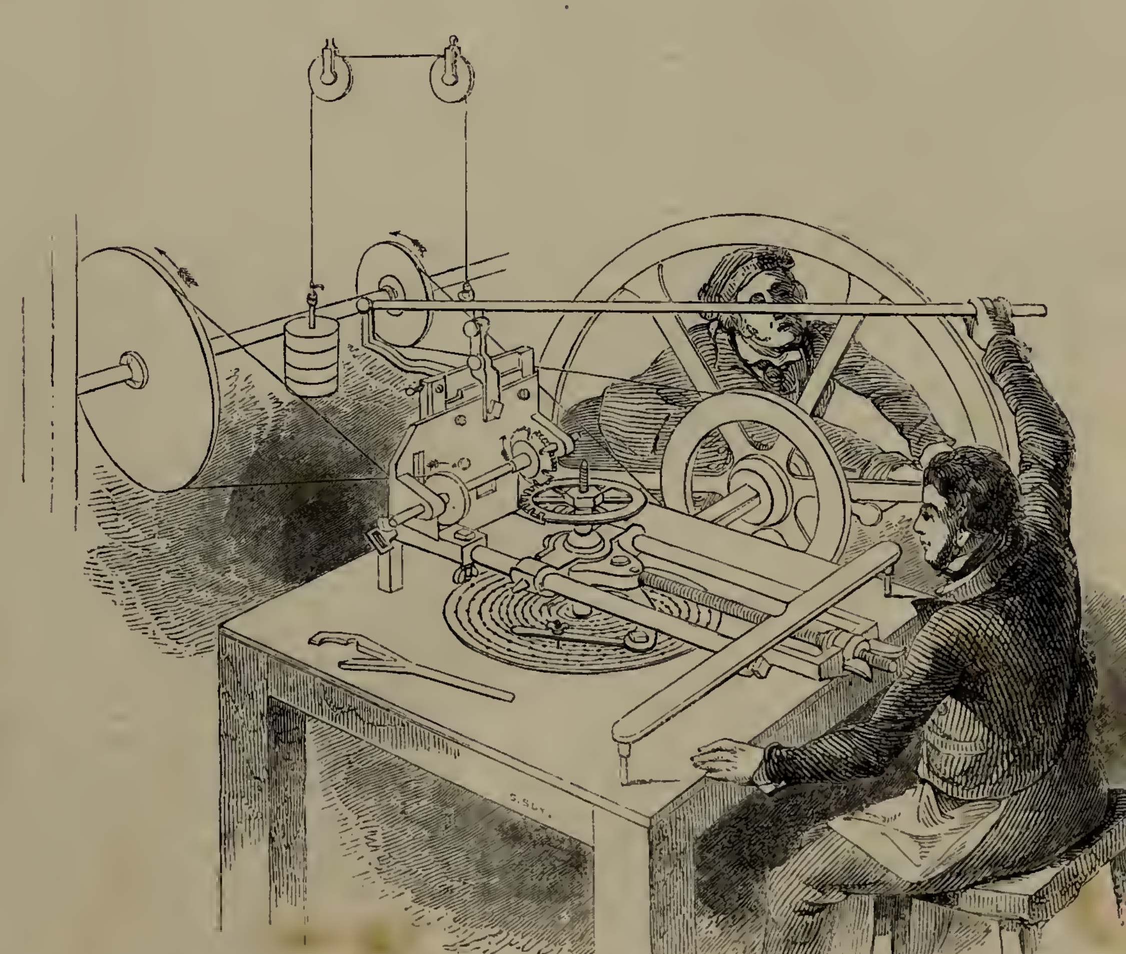


1559.—Mechanism of a Common Watch, viewed edgewise.

1557.—Mechanism of a Repeating Watch.



1558.—Mechanism of a Pedometer.



1560.—Cutting the Teeth of Clock-Wheels.

speakers of their right to the full time allowed, that if any interruption to their speech occurred, they would stop the flow of water in the clepsydra until the interruption was passed; and if any one of them had ended his speech before the prescribed time, he was permitted to lend the remaining water to any other speaker, who might in return render him a similar service on any other occasion. Oratory might, perhaps, assume a different character if "learned counsel" and "honourable members" in general were limited in a similar way.

The *Hour-glass*, or *Sand-glass*, is a very pretty mechanical aid in measuring time, since the material with which it is filled, dried sand, has a singular property in respect to the equability with which it flows through a small orifice. Some of these instruments are hour-glasses (whence the name for the whole of them), some three-minute glasses for egg-boiling, and some half-minute glasses, in nautical matters; these obtain their respective names from the period which elapses during the flow of sand through a small opening leading from one receptacle to another, the quantity of sand and the size of the opening being the circumstances which regulate the length of this period. They are all shaped pretty much alike, being formed of two pear-shaped glass vessels joined together at their smaller ends, with a small orifice at the point of junction, and a frame or stand for containing them. The two glasses are, in the first place, blown to the proper size in the same way as flint-glass vessels generally, and into one of these is placed the proper quantity of dried and sifted silver sand. The small ends of the two bulbs or vessels are then fused together by the heat of a blow-pipe, leaving an aperture for the sand to flow from one into the other: the chief art here is in maintaining the orifice at a size just large enough, and no more, for the passage of the sand in the proper time. The bulbs are said to be made in France in the following manner: four bulbs are blown from one piece of glass tube in such a manner that all are connected together in one line with narrow lengths of tube between them. The two end bulbs are opened in the form of a funnel, and thus form two stands or pedestals for the instrument. One of the ends of the small central tube is stopped, and the sand is introduced at the other; both the ends are then permanently closed, and the two central bulbs then form the two parts of an hour-glass. It has been stated that egg-shell baked and finely powdered answers better for this purpose than sand.

Pendulum Clocks and Spring Watches.

There seems to be at the present day a general convergence of opinion towards the superiority of time-measuring instruments which depend on the movement of a system of wheels, derived either from the descent of a weight by the force of gravity, or from the recoil of a spring when pulled out of its natural course. The results obtained by these means are quite surprising, and equal anything, perhaps, which the arts present. A common house-clock and a church-clock are types of the former of these two kinds; a pocket-watch and a chronometer are types of the latter. In the pendulum clock there is a line or rope having a metal weight at the lower end, and this weight is really the source of movement in the whole machine. The natural tendency which all bodies have to fall downwards acts on the weight as well when fixed to a string as if left unsupported, and the spring becomes itself pulled; the rope, however, cannot descend without causing the rotation of a barrel to which it is attached. If this were all the mechanism, the weight and rope would descend and the barrel would rotate unchecked, increasing in speed as they advance; but there are sundry small pieces of mechanism, including the "pendulum," which regulate this descent and rotation, and the motion is thus made tolerably uniform. When the barrel has rotated for such a time that all the rope is unwound from it, the clock requires to be "wound up," which is effected by simply pulling a small weight in a small clock, but by a winch-handle in a large one.

The barrel and pendulum, then, of a clock have a uniform motion given to them by the descent of a weight; and this motion is communicated from one wheel to another by means of teeth and pinions of various forms, until the two axes are moved which carry the "hour-hand" and the "minute-hand." If a proper regulation of the wheelwork has been made, these two hands or indexes will indicate the correct hour of the day. Most clocks, however, do something more than thus silently indicate the time—they *strike*, either at the hours only, or at the quarters also. In such case there is a separate moving power for the striking mechanism, as distinct from the "going" mechanism. There are a weight, a cord, and a barrel distinct from the other; and these work mechanism which move a hammer intended for striking on a bell. At a particular time the two sets of mechanism are brought mutually to act on each other, so that the mechanism of the clock causes that of the bell to act in the required manner.

In a pocket-watch or a chronometer things are differently managed. Here there is a spring coiled up in a barrel and joined at one end to a chain; the chain is wound round a conical-shaped support called the "fusee." The key of the watch is made to act directly on this fusee in such a manner as to draw off the whole of the chain from the barrel to the fusee. The spring contained within the barrel is, by this action, stretched out of its natural position, and for a period of about thirty hours (in a common watch) it exerts a constant pulling force, from a tendency to return to its former position. This pulling force has the effect of drawing off the whole of the chain from the fusee to the barrel; but as this cannot be done while the fusee remains fixed, there is a provision for making the fusee rotate on its axis and give off the chain freely. A revolving motion is thus produced within the watch, and nothing more is wanted than a system of wheelwork to transmit this movement to the hands which indicate the hours, minutes, and seconds. Thus it will be seen that in a common clock the first movement is given by the gravitation of a suspended weight; while in a watch it is given by the recoil of a steel spring stretched out of its wonted position.

Although the cause and nature of the movement are thus explained, there is a great deal of delicate mechanism required for the "regulation" of these complicated instruments; that is, the maintenance of a constant rate of movement, so that the clock or watch shall not be either "too fast" or "too slow." This has proved to be by far the most difficult matter connected with the manufacture of these instruments. In the common commercial arrangements of society punctuality in respect to time is of much importance; but in nautical matters and in the operations of an observatory it is of still more importance. Hence the *pendulum* arrangements of clocks and watches have become of the highest practical importance. An astronomical clock is the most delicate of those which are moved by a weight, while a chronometer takes the lead among those which are moved by a spring; but both alike require a pendulum to regulate the movement, although the mode in which this pendulum acts is different in the two cases. In a clock the pendulum is a vertical rod which oscillates to and fro, and the arrangements at the lower end of the pendulum are for the purpose of accommodating its length according to the expansion of the materials in warm weather or their contraction when cold; this compensation being so regulated that the pendulum shall perform all its oscillations in equal times, whereby the movements of the hands of the clock become also uniform in speed. In a watch the pendulum is a wheel, analogous to the fly-wheel of a steam-engine, in so far as it regulates the equable movement of the wheelwork generally. As the steel of which this wheel is made is susceptible of expansion and contraction by heat and cold, like every other substance, the object has been so to combine different pieces or different kinds of metal together as to neutralize the effect of these changes and make the movement of the instrument uniform. These are the labours which have given celebrity to the names of Harrison, Frodsham, Arnold, Graham, Dent, and other chronometer-makers, whose general arrangements of the mechanism of these instruments, and especially of the compensation pendulums, have attained a degree of accuracy and beauty scarcely conceivable.

How complex are the internal parts of a watch, every child knows; and it will suffice here to give a few representations of such, without attempting the task of explaining minutely the object and purpose of each little piece of mechanism; an explanation which would be both difficult to give and tiresome to read. Fig. 1553 shows two forms of the compensation balance or pendulum, for regulating the movements in chronometers. Fig. 1554 is a part of the apparatus connected with the striking of a large clock; the wheel, of which a part is shown, being set in motion by the general mechanism of the instrument, and the teeth or cogs on its edge acting on a system of levers which govern the movement of the hammer. In Fig. 1555 is the complex internal mechanism of an eight-days clock, moved by a spring like a watch, and not by a weight like a common clock; there are one barrel and fusee for the "going" mechanism, and one for the "striking," the two being put mutually into connexion by some intervening wheelwork. In Fig. 1556 part of the mechanism of this clock is shown detached, by which it will be seen how curiously formed are many of the small pieces of apparatus connected with the striking mechanism and with the fusee. In Fig. 1557 is some of the elaborate mechanism of a "repeating watch," or one which not only indicates the hours by the hands, but also strikes them on some kind of bell or sonorous piece of metal. In Fig. 1558 are the two faces of a small and ingenious instrument called a Pedometer, the object of which, when the instrument is adjusted in a particular way to the person, is to measure the distance which a pedestrian has walked. In Fig. 1559 is represented a common watch, seen edgewise, with the dial-plate removed. In Fig. 1560 is shown the machine by the action of which the teeth are cut in the wheels of watches and clocks. In Fig. 1566 a representation is given of the principal part of the mechanism in one of the large church clocks of London; in which the size of the various parts of the clock may be pretty nearly estimated by the height of the man shown in the act of winding up the mechanism.

The large church clocks are made by a very small number of persons; the clocks of an inferior description are made in various parts of England; but the making of pocket watches has centred in a most remarkable way in the parish of Clerkenwell in London; to so great a degree, indeed, that there is scarcely a street in that district which does not contain some artificers employed in this way; while in some of the streets almost every house contains inmates so employed. The general subdivision of the manufacture was thus described in 'London' (No. 59):—

"An ordinary gold or silver watch passes through considerably more than one hundred hands, each workman performing a part of the operation to which his whole attention is directed, and differing from that of every other. It is perhaps still more surprising that this minute subdivision relates, after all, only to what may be termed the finishing of a watch; for the watch 'movements' are made almost wholly in Lancashire. On opening a pocket-watch, we see that there are two parallel brass plates, having between them the greater portion of the wheels belonging to the watch: this portion is known by the manufacturers under the general name of the 'movement;' and is that to which we here refer. Whether it is that the Lancashire watch-movements excel those which could be made in Clerkenwell in excellence or in price, we shall not attempt to decide; but certain it is that almost every English watch, of whatever quality, has its 'movement' made in Lancashire.

"Let us follow the 'movement' in its progress towards completion. On its arrival in London it is purchased by the 'watch-manufacturer,' a tradesman who hires the services of the numerous sub-branches alluded to above. It is to be supplied with the 'motion-work,' or mechanism in connexion with the hands; with a 'spring,' and connecting mechanism; with an 'escapement,' or apparatus for securing the uniform 'going' of the watch; with a 'case,' generally of silver or gold; with a 'dial,' generally enamelled, but sometimes of chased metal; with a 'glass,' and with other appendages. The manufacturer gives these various parts to be made by certain persons who undertake definite portions; and these parties further subdivide to a degree of minuteness scarcely credible. The 'escapement-maker,' for instance, so far from being one workman who manufactures everything relating to an escapement, may be a 'duplex-escapement' maker, or a 'lever-escapement' maker, or a 'horizontal-escapement' maker—he may also have under him many workmen, each of whom is employed in, and is competent only to the manufacture of, some one particular part of some one kind of escapement. The enamelled dial of the watch, too, instead of being perfected by one man, passes through the hands of several: one man forms the dial out of sheet copper; another coats it with the beautiful enamel; a third paints the letters and figures in enamel colours; and a fourth adjusts the dial to the other parts of the watch. The case, in like manner, passes through many hands; for, besides the workmen employed in actually making it, there is the 'secret-springer,' who forms the mechanism by which the two halves of the case close together; the 'engine-turner,' who engraves those curious devices which ornament the cases of some watches; and the 'pendant-maker,' who constructs the loop and apparatus by which the watch is suspended from the chain, guard, or watch-ribbon. The 'hands' of the watch form a branch of the manufacture totally distinct from the others; so does that of the 'watch-key;' and even that of the little 'index,' by which we regulate the going of the watch when too fast or too slow. Some of the wheels of the watch are considered so far distinct as to have their teeth formed by workmen who do not cut the teeth of other wheels. The 'fusee,' likewise, a conical piece of brass on which the chain is wound by the watch-key from the barrel, is made by one who is wholly employed as a 'fusee-cutter.' In the 'jewelling' of a watch, some men are employed in preparing the stones, and others in making the pivot-holes. Thus, we might go on dissecting a watch to its minutest parts, and showing that the more we do so the more numerous shall we find the subdivision of workmen who made the watch."

Remarkable specimens of Clockwork.

There have been produced, in some few instances, clocks of most complex manufacture, in which the springs and wheelwork effected much more than merely indicating the hours of the day. The advancement of astronomical knowledge has rendered such productions less valuable than they once were; but they still remain as examples of what man's ingenuity can effect.

In the Cathedral of Lübeck is a very ancient clock, of singular construction. It is calculated to answer astronomical purposes: representing the phases of the sun and moon in the ecliptic, the moon's age, a perpetual almanac, and many other contrivances. The clock has an inscription to the effect that it was placed in the church on Candlemas-day in 1405. Over the face of it appears an image of our Saviour, and on either side of

the image are folding doors, so constructed as to fly open every day when the clock strikes twelve. At this hour, a set of figures, representing the twelve apostles, come out from the door on the left hand of the image, and pass by in review before it, each figure making its obeisance by bowing as it passes that of our Saviour, and afterwards entering the door on the right hand. When the procession terminates, the doors close.

As long ago as the ninth century, a clock is said to have been sent by Haroun al Raschid, the celebrated Caliph of Bagdad, to the Emperor Charlemagne, in which there was a degree of mechanical ingenuity displayed which we should hardly have expected to find in those times. The hours were struck by the falling of twelve brass balls upon a bell. It had also twelve horsemen, who came out one at a time, at separate doors, which they opened, and closed again. This clock contained a system of wheelwork, but it is said to have been moved by the falling of water, in the same way as a clepsydra, and not by a weight or a spring.

About the middle of the fourteenth century, an Italian named Giacomo Dondi erected at Padua a clock which, besides the hour of the day, showed the course of the sun in the ecliptic and the places of the planets. This clock brought great reputation to its maker. He was dignified with the title of Horologius or (in Italian) Orologio, signifying "clock" or "clockwork;" and his descendants still retain the name of Dondi Orologio. Almost every court in Europe was desirous of possessing some such specimen as this; and ingenuity became largely directed into this channel.

There was some years ago at Lyons, and perhaps still is, a clock which exhibited, on different dial-plates, the annual and daily progress of the sun and moon, the days of the year, the length of the day, the civil calendar, and the ecclesiastical calendar. The hours of the day were indicated by the crowing of a cock, thrice repeated, after it had flapped its wings and made other movements; and when the cock had ceased crowing, figures of angels appeared, who performed the air of a hymn by striking various bells. A set of moving figures and the descent of a dove indicated the Annunciation of the Virgin. On one side of the clock was an oval dial-plate, where the hours and minutes were indicated by means of an index, which had a peculiar property of lengthening or shortening itself, so as to adapt its length to the varying diameter of the oval plate.

The obsequious homage so often paid to Louis XIV. affected the clockmakers as well as other people; for they produced many pieces of mechanism calculated to flatter the vanity of the "Grand Monarque." One of these was a clock constructed by Martinot. Just before the hours were to be struck, two cocks, on the corners of a small edifice, crowed alternately, clapping their wings. Then two side doors of the edifice opened, and at these appeared two figures bearing cymbals, which were forthwith played with clubs. When these had retired, a central door was thrown open; and a pedestal, supporting an equestrian statue of the king, issued from it. A group of clouds, separating, gave a passage to a figure of Fame, which descended and hovered over the statue. A tune was then performed by bells; after which the two figures re-entered: the two sentinels raised up their clubs, which they had lowered as a symbol of respect; and the hour was then struck. This clock was deposited in one of the apartments at Versailles.

There is at Strasbourg a celebrated clock, which seems to eclipse all others in the complexity and variety of its mechanism. It was constructed during the latter half of the sixteenth century. Almost every astronomical phenomenon which was known in those days has been represented, with more or less of success. There is one great sphere which revolves on its axis from east to west in twenty-four hours: this represents the apparent rising and setting of the various heavenly bodies, though occasioned by the daily rotation of the earth itself. Within or connected with this sphere are two smaller globes: one to represent the sun, which runs through the signs of the Zodiac once every year; and the other the moon, which goes through her lunations in twenty-eight days. The north pole of the heavens is noted by a star made of brass; the zenith is noted by the figure of an angel placed above; and the mechanism which moves the spheres is concealed in the body of a pelican, placed under them. Another part of the clock contains two circles one within another, the inner one eight feet, and the outer one nine feet in diameter. The larger one rotates from north to south once in a year; and it has two figures of angels attached to it, one of whom points to the day of the week, and the other to the day of the week exactly half a year afterwards. The smaller one rotates from south to north once in a hundred years, and has inscribed on it many phenomena and festivals: such as the year of the world, the year of the Christian era, the ecliptic, the equator, the leap-year, the moveable feasts, and the dominical letter—all of which are indicated for the successive years by index hands; as also the eclipses of the sun and moon for a period of about half a century after the construction of the cloak.

There are many other curious contrivances in this piece of mechanism. The seven planets (as they were deemed in those days, including the sun and moon) are represented by seven of the heathen deities, who are made to appear each at the proper time to indicate the day which is placed under his auspices. In another part is a dial for the minutes; on the north side a child moves a sceptre at every stroke of the clock; while on the south side another child holds an hour-glass in his hand, the sand from which runs while the clock is going, and when the hour has struck he reverses the glass. Above the minute-dial is an hour-dial, of which the outer circumference contains the hours; while within this is contained an astrolabe, whereon is shown the aspect and position of every planet, and the opposition of the sun and moon. At another spot the age and phases of the moon are represented.

Besides the above astronomical features of the clock there are others of a more fanciful, but less scientific kind. There are four little bells, on which the quarters of the hours are struck, each quarter being accompanied by its own peculiar exhibition. At the first, equivalent to a "quarter past" the hour, a figure of a little boy comes forward, strikes the first bell with an apple, and passes onward towards the fourth bell; at the second quarter a second boy strikes two bells with a dart, and passes to the place before occupied by the first boy; at the third quarter comes forth an armed man, who strikes three bells with a halbert, and then passes to the second bell; at the fourth quarter an old man comes out with a staff, with which he strikes four bells, and then passes to the third one. At each quarter a figure of Death comes forward, and endeavours to catch the boy or man who had struck the bell; but on the other side also comes forward a figure of our Saviour, who drives Death in again. At the last quarter, however, Death is allowed to strike the hour on the large bell with a bone of a skeleton. The four quarter figures have mutually changed places, so that each one in his turn becomes placed by the side of one of the bells. At the top of the clock is a tower containing chimes, which play at three, seven, and eleven o'clock, each time a different tune; and when this chime has ended, a figure of a cock stretches out his neck, shakes his comb, claps his wings twice, and crows twice.

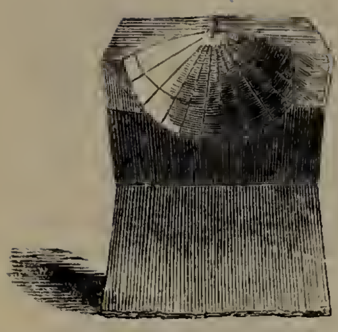
The description of this extraordinary piece of mechanism applies to the state in which it existed many years ago, when all its arrangements were in proper order. Whether the clock ever really did perform all these wonders, or in what state it exists at the present day, we are not aware.

It is evident, on a slight consideration, that the same kind of ingenuity which is displayed in these clocks is also applicable to the various *Automata* that have been made from time to time. Wooden pigeons having the power of flying; swans capable of swallowing artificial fish; peacocks which could unfold their tails and erect the crest; humming-birds that would flutter, fly, and sing; steel spiders that would crawl upon a table; caterpillars, mice, and serpents that would imitate the movements of those animals; an opera-stage, with all the performers strutting about by mechanical aid; the celebrated duck constructed by Vaucanson, which not only waddled, quacked, and moved like a duck, but actually drank water and ate food; a carriage and horses, with a lady, a page, and a footman, all of whom demeaned themselves in accordance with the equipage to which they belonged; dogs which gnash their teeth and bark on the removal of fruit which they are set to guard; figures of men that will write, draw, speak, calculate, and tell fortunes; the automaton flute-player of Vaucanson; the pipe and tabor player by the same mechanician; the pianoforte-player by Maillardet; the trumpeter by Maelzel;—all have had their day of admiration—all were moved by elaborate systems of wheelwork and other machinery—and all are, to this extent, analogous in character to clocks and watches, though infinitely less valuable to society. If Vaucanson had made mechanical spinning-wheels instead of mechanical ducks, his name would not now be so limitedly known.

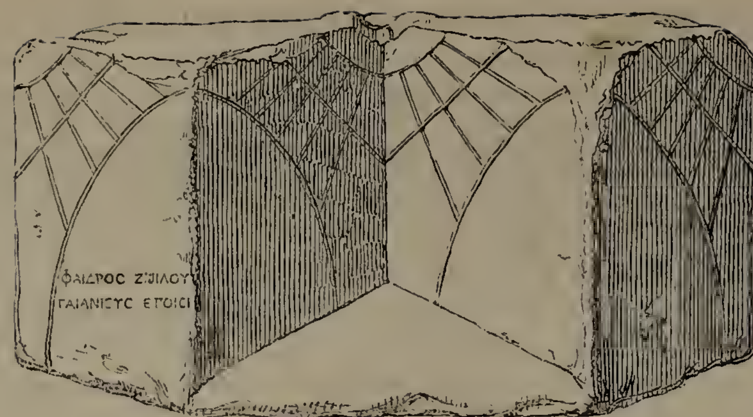
IN bringing this volume to a close, it may be well to remark that the particular mode adopted for classifying the Industrial Arts lays claim to no especial merit on the ground of completeness or precision. So intimately do all the Arts blend one into another, so numerous are the sub-branches into which each may be divided, and so varied the aspects under which each one may be viewed—whether in respect to its materials, the purpose to which it is to be applied, or the kind of skill required in its prosecution—that any classification must be only an approach towards correctness. If the arrangement is such as to include the more prominent among the Arts, and to present the broad principles of each with tolerable distinctness, this is all that, in a popular work, can be aimed at or hoped for.

It can hardly fail to be remarked by any one who views the productive Arts in relation to their particular destination, that—besides the mutual blending above alluded to—there is an intimate connexion between their *taste* or *beauty* and their *utility*. Taste is (in principle, if not in degree) as much a marketable commodity as iron or oak; since beauty of form and appearance is certainly one of the elements for determining the value of that which Art has wrought from the rough materials furnished by Nature. Whether it be a fountain for supplying water; a lamp or a gas-tube for supplying light; a stove for containing fuel; a piece of cloth for a garment; an assemblage of wood and stone and brick for a dwelling; a room-wall, a ceiling, a carpet, a table, a chair, or any other component part of room furniture; a stately ship or a pleasure barge; a coach or a railway carriage; an article of metal or of stone, among the thousands in everyday use; a book; a musical instrument; an instrument or apparatus for aiding in the prosecution of science;—whatever may be the object on which Industrial Art is employed, there are always means for adding to its utility another element—that of elegance or taste; and this superadded quality is, with exceptional cases here and there, felt and valued as an important feature.

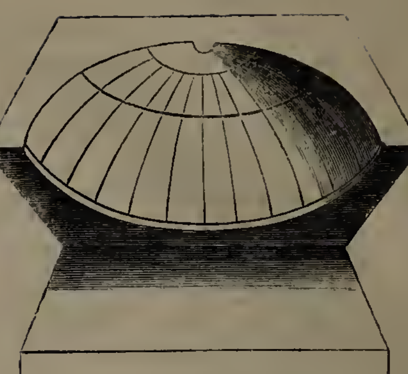
In this way a link is furnished whereby the Useful Arts are connected with the Fine Arts; and a rapid glance at the former of these two classes will fittingly be followed, therefore, by a similar glance at the latter.



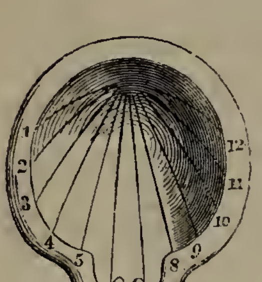
1561.—Ancient Sun-dial.



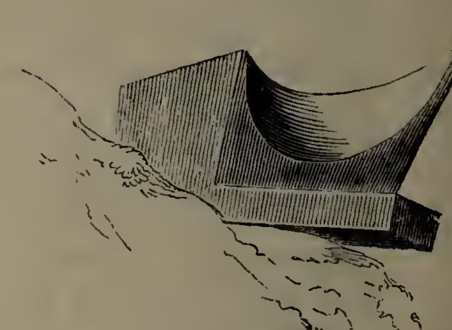
1562.—Ancient Sun-dial.



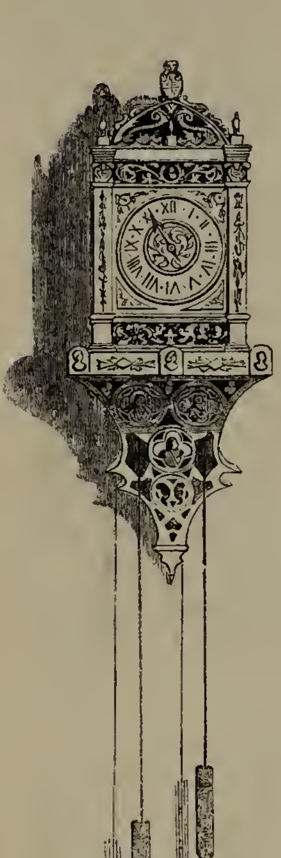
1563.—Ancient Sun-dial.



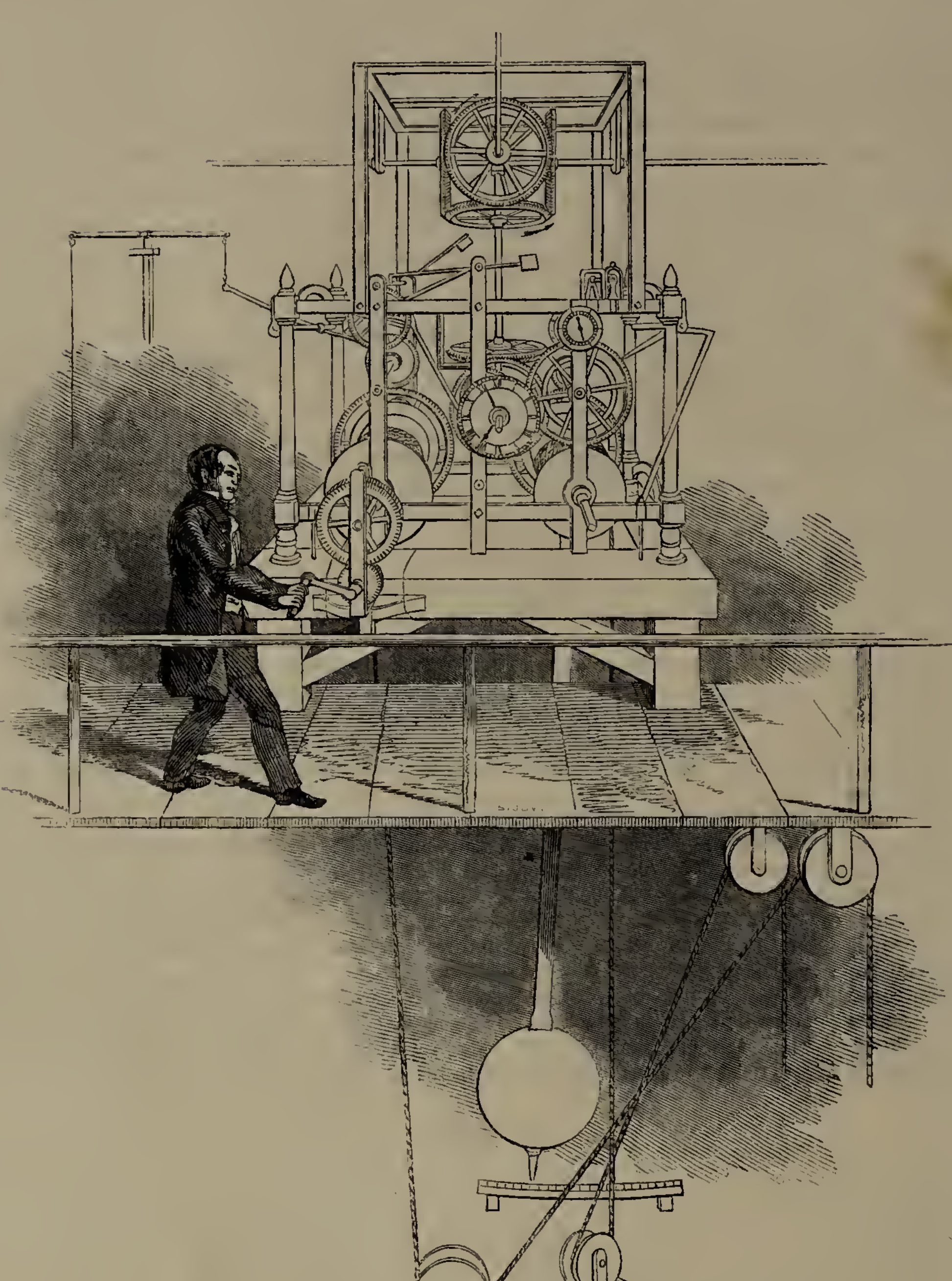
1564.—Ancient Sun-dial.



1567.—Ancient Sun-dial.



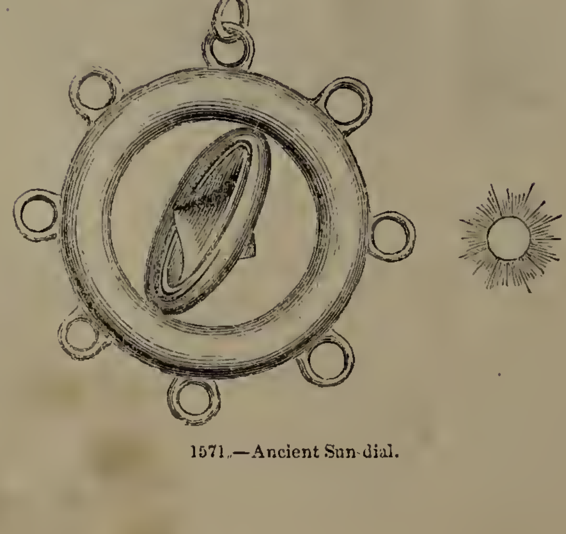
1565.—Clock at Strawberry Hill.



1566.—Clock of St. Ann's Church, Limehouse.

1568.—Ancient Sun-dial.

1569.—Shepherd's Dial.



1571.—Ancient Sun-dial.

1570.—Clock at Hampton Court.

INDEX

TO THE

ENGRAVINGS OF USEFUL ARTS.

FRONTISPIECE.

This coloured plate is a fac-simile of a singularly beautiful piece of Tapestry, now in the possession of the Right Honourable Lord Brougham, who has kindly permitted this copy to be made. The celebrated Virgin, Child, and John, of Raphael, known as the 'Virgin in the Chair,' is a circular picture, said to have been painted on the top of a beer-barrel. The circular boundary of the picture extending very little below the feet of the infant, the figure of the Virgin is consequently what is called a three-quarter length. All beyond this circle in the lower part of the Tapestry is so much added to the picture. There can be no doubt that the Tapestry is a very ancient piece of work; and whoever was the artist who thus extended the original design, his task was accomplished very skilfully. Our colours give a faithful representation of the colours of the Tapestry.

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